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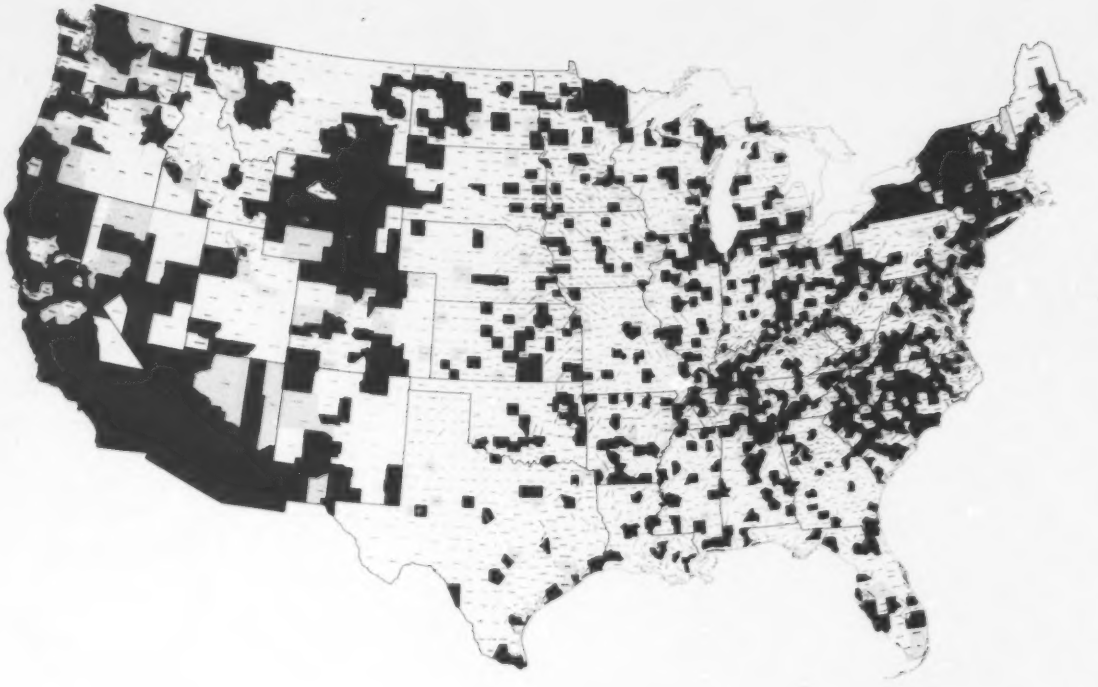

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16. ABSTRACT

This report presents national and regional trends in air quality through 1976 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide and oxidants. The change in the number of people exposed to air quality levels above the National Ambient Air Quality Standards is emphasized for four major metropolitan areas: the New York-New Jersey-Connecticut Air Quality Control Region; the Los Angeles Basin; the City of Chicago and Metropolitan Denver. All areas show long-term improvement in reducing adverse pollution levels. A major feature of this report is the presentation of multi-color air quality maps for total suspended particulate, sulfur dioxide and photochemical oxidants. The maps are included to respond to the often asked question: "How does air quality vary across the United States?" The analyses in this report are based on the data collected through the extensive monitoring activities conducted by Federal, State and local air pollution control agencies. Nationwide emissions for the period 1970-1976 are also presented.

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Office of Air and Waste Management
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December 1977

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NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1976

1. INTRODUCTION AND OVERVIEW

1.1 GENERAL OVERVIEW

Long-term progress (1970-1976) can be seen in achieving compliance with the National Ambient Air Quality Standards (NAAQS) for total suspended particulate, sulfur dioxide, and carbon monoxide nationally and for photochemical oxidants in California. In the short-term, however, some reversals have taken place for total suspended particulate with many areas experiencing increases between 1975 and 1976. Where photochemical oxidants are measured outside California, the trend appears basically stable over the 1973-1976 period. Nitrogen dioxide trends are stable in California; nationally, however, nitrogen dioxide levels tend to be increasing based mostly on 3 years of data. There are still insufficient data, however, to draw any definite conclusions on nitrogen dioxide levels outside California.

Air quality progress is measured by comparing the ambient air pollution levels with appropriate primary and secondary NAAQS for each of the pollutants. Primary standards protect the public health, and secondary standards protect the public welfare as measured by effects of pollution on vegetation, materials, and visibility. The standards are further categorized for long- or short-term exposure. Long-term standards specify an annual mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages that may not be exceeded more than once per year.

Data for analysis in this report were obtained primarily from the U.S. Environmental Protection Agency's National Aerometric Data Bank (NADB). These data are gathered primarily from State and local air pollution control agencies through their monitoring activities.

This is the sixth report on air pollution trends issued by the Environmental Protection Agency.[1-5] The report updates the population exposure analyses for the New York-New Jersey-Connecticut Air Quality Control Region, accounting for 17 million people, and the Los Angeles Air Basin, accounting for 8 million people.[5] Population exposure analyses are also featured for the City of Chicago and Metropolitan Denver. Changes in the population exposed to ozone and nitrogen dioxide levels above the standard were stressed in the Los Angeles study, while changes in the population exposed to total suspended particulate levels above the NAAQS were examined in the other cities.

A major feature of this report is the presentation of multi-color air quality maps for total suspended particulate, sulfur dioxide, and photochemical oxidants. These maps are included to respond to the often asked question: "How does air quality vary across the United States?"

The major findings of these investigations are as follows:

1. The general long-term improvement in total suspended particulate reversed itself between 1975 and 1976 with many areas experiencing increases. The likely explanation for this phenomenon is meteorological. Large areas of the country experienced drought during 1976. These extremely dry soil conditions increased the likelihood of wind-blown dust contributing to ambient particulate levels.

2. A major decrease was observed in the population exposed to high particulate levels in Metropolitan New York, Chicago, and Denver. The greatest improvement occurred in the New York-New Jersey-Connecticut Air Quality Control Region, where the percentage of the population exposed to particulate levels above the annual primary health standard decreased from 60 percent in 1970 to 0 percent in 1976. Similarly, Chicago decreased from 100 percent in 1970 to 64 percent in 1976; Denver decreased from 83 percent in 1970 to 74 percent in 1975.

3. The long-term improvement in the Los Angeles Basin in the percentage of days when the 1-hour oxidant standard was violated, reversed itself in 1975 and 1976. People in the Basin were exposed to a concentration above the standard on an average of 176 days per year in 1965 and 1966, 105 days per year in 1973 and 1974, and 112 days in 1975 and 1976. This slight degradation over the last 4 years appears to be due to an increase in the number of days with poor meteorological dispersion.

4. The early 1970's saw dramatic decreases in ambient sulfur dioxide levels in the Nation's urbanized areas. Since then, national trends have been much more stable and violations of the sulfur dioxide standard are generally confined to areas around specific sulfur oxide sources. In contrast to TSP, levels between 1975 and 1976 are relatively stable. Of the 722 sulfur dioxide trend sites, 11 percent increased, 12 percent decreased, and 76 percent remained stable between 1975 and 1976.

5. Approximately three-fourths of the 202 carbon monoxide trend sites showed improvement. California sites had a slightly higher rate of improvement, 7 percent per year in California versus 6 percent per year outside California for sites with 4 or more years of data. In 1976, 49 percent of the sites report their all-time-low 90th percentile values.

6. Photochemical oxidants ranks today as one of the most serious and pervasive air pollution problems in this country. In 1975, 86 percent of the ozone sites reporting to the NADB exceeded the NAAQS of 160 $\mu g/m^3$. The California sites were basically stable during the 1970-1976 period, while the non-California sites show a slight tendency for increasing patterns with 55 sites "up" and 46 sites "down."

7. Nitrogen dioxide trends are stable in California, but outside of California there is a preponderence of increasing patterns with twice as many sites showing "up" patterns than "down" patterns (145 versus 77 sites). Since most of these sites have only 3 years of data, there are still insufficient historical data to draw any definite conclusions on nitrogen dioxide trends outside California.

1.2 ACKNOWLEDGMENT

The Monitoring and Data Analysis Division would like to acknowledge William F. Hunt, Jr., for the overall management, coordination, and direction given in assembling this report.

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2. FEWER PEOPLE EXPOSED TO ADVERSE AIR POLLUTION IN MAJOR METROPOLITAN AREAS

In the *National Air Quality and Emissions Trends Report, 1975*, the trends in the population exposure were examined for two major metropolitan areas - the New York-New Jersey-Connecticut Air Quality Control Region (AQCR) and the Los Angeles Air Basin.[1] In this report, these analyses are extended through 1976, and population exposure trends in Chicago and Denver are reported as well. The population exposure analyses examine improvements in terms of decreases in the numbers of people being exposed to pollutant levels above the National Ambient Air Quality Standards (NAAQS). Because the purpose of primary standards (health-related) is the protection of public health, these studies have been undertaken, in cooperation with EPA's Regional Offices, to measure the effectiveness of emission control plans in reducing air pollution levels below the NAAQS. Both air quality data and population data are factored into this "population exposure" approach.

The change in population exposure to high particulate levels was determined for the New York-New Jersey-Connecticut AQCR and the cities of Chicago and Denver. Photochemical oxidants and nitrogen dioxide were examined in the Los Angeles Basin. These areas were selected because they are among the nation's largest metropolitan areas and also have extensive air monitoring networks. The New York-New Jersey-Connecticut AQCR accounts for 17 million people and has a total of 161 suspended particulate monitors, which provide sufficient historical data to examine trends. Chicago accounts for 3.4 million people and has 16 sites with historical data; Denver has a population of 1 million and 19 sites for conducting trends. The Los Angeles Air Basin has a population of 8 million people and has extensive oxidant and nitrogen dioxide monitoring networks.

For each metropolitan area, the time period analyzed was based on availability and completeness of air quality data. In the population studies related to particulate, the data for New York and Chicago were sufficiently complete to permit examination of individual years. In the Denver analysis, 3-year-average periods were employed to make the best use of available data. For the population study of oxidants and nitrogen dioxide in Los Angeles, a 12-year period could be examined because of the long-term monitoring program in that city.

Meteorology is recognized to be an important factor affecting air quality trends. Where possible, meteorological variables were included to aid in the interpretation of the results.

The analyses required the merging of a local population and air quality data to compute several measures of pollutant exposure. In order to accomplish this task, 1970 population data for all areas were "gridded" into a network of population receptor points; each point represented a subset of the areas' total population. A spatial interpolation procedure[2] was then employed to estimate the air quality at each population receptor point. This procedure yielded estimates of population exposure for the total population by place of residence. The progress in reducing both the number of people exposed and the frequency of exposure to pollutant levels above the NAAQS levels is discussed in the following section.

2.1 MAJOR DECREASE IN POPULATION EXPOSED TO HIGH PARTICULATE LEVELS IN NEW YORK, CHICAGO, AND DENVER

The greatest long-term improvement occurred in the New York-New Jersey-Connecticut Air Quality Control Region, where the proportion of the population exposed to concentrations in excess of the annual primary health standard of 75 $\mu g/m^3$ decreased from 66 percent to 0 between 1970 and 1976. Considerable progress was also seen in Chicago; the proportion of the

population exposed to TSP levels greater than the annual primary standard fell from 100 percent in 1970 to 64 percent in 1976. In Denver, the percentage of the exposed population dropped from 83 percent in 1970 to 74 percent in 1975.

2.1.1 Major Decrease in Population Exposed to High Particulate Levels in New York-New Jersey-Connecticut Air Quality Control Region

The change in number of people exposed to total suspended particulate (TSP) matter in the New York-New Jersey-Connecticut AQCR was examined for the period from 1970 to 1976. Overall, significant progress has been made in reducing population exposure to annual average TSP levels within the AQCR. Switching to cleaner fuels and implementing particulate control measures have reduced annual concentration levels by 30 percent. This improvement means that no one lives in areas exposed to concentrations in excess of the annual primary health standard of 75 $\mu g/m^3$.

2.1.1.1 Methodology - Air quality data produced by the TSP monitoring network in the Tri-State Region were examined, together with demographic statistics, to determine the change in resident populations exposed to ambient air pollution of various levels. In 1970, about 17 million people were living in the study area. Population density in 1970 is depicted in Figure 2-1. The most densely populated areas were found in the urban core composed of most of New York City and parts of northeastern New Jersey. TSP concentrations are generally the highest in these areas.

Figure 2-2 presents the locations of the 161 TSP monitors that provided the air quality data for this analysis. Three years, 1970, 1973, and 1976, were selected to demonstrate the change in population exposure over time. At least 107 monitoring sites produced a valid year* of data in each of these years. TSP estimates for other sites were obtained by considering the relative annual changes among all 161 TSP monitors during 1970-1976.

A network of 215 receptor points was used to interface the air quality and population data. Each receptor point represented a subset of the total population, as well as subsets of the less mobile but susceptible school-age and elderly populations. This network, displayed in Figure 2-3, provides complete area coverage, with more detail afforded densely populated areas. The TSP air quality of each grid point of the network was estimated from the actual monitoring data by spatial interpolation. The estimates of population and air quality were then used to characterize the region.

2.1.1.2 TSP Air Quality Pattern–Isopleths of average TSP during 1970, 1973, and 1976 are shown in Figure 2-4. In 1970, approximately 21 percent of the region had TSP concentrations greater than the primary NAAQS. The affected areas included New York City and adjacent populated parts of New Jersey, New York State, and Connecticut. At the same time, 51 percent of the land area exhibited TSP concentrations over the secondary TSP "welfare" standard of 60 $\mu g/m^3$.

By 1973, substantial reductions in TSP could be seen. The land area exposed to concentrations in excess of the annual primary standard has been reduced to 2 percent of the Air Quality Control Region. The affected areas were mostly in the central portion of the region consisting of parts of New York City and adjacent New Jersey. The area with concentrations above the secondary standard was also reduced; the affected area constituted about 15 percent of the AQCR.

In 1976, only one TSP monitoring site in Jersey City, N.J., produced an annual TSP concentration above the primary standard. The reported concentration was 78 $\mu g/m^3$. Because this monitor was adjacent to monitors measuring lower concentrations, Figure 2-4 does not show any areas above the primary standard. The land area subjected to concentrations above the secondary standard has also continued to shrink. The affected area is less than 7 percent of the AQCR.

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* A valid year of data is based on a minimum of five 24-hour-average values per calendar quarter.

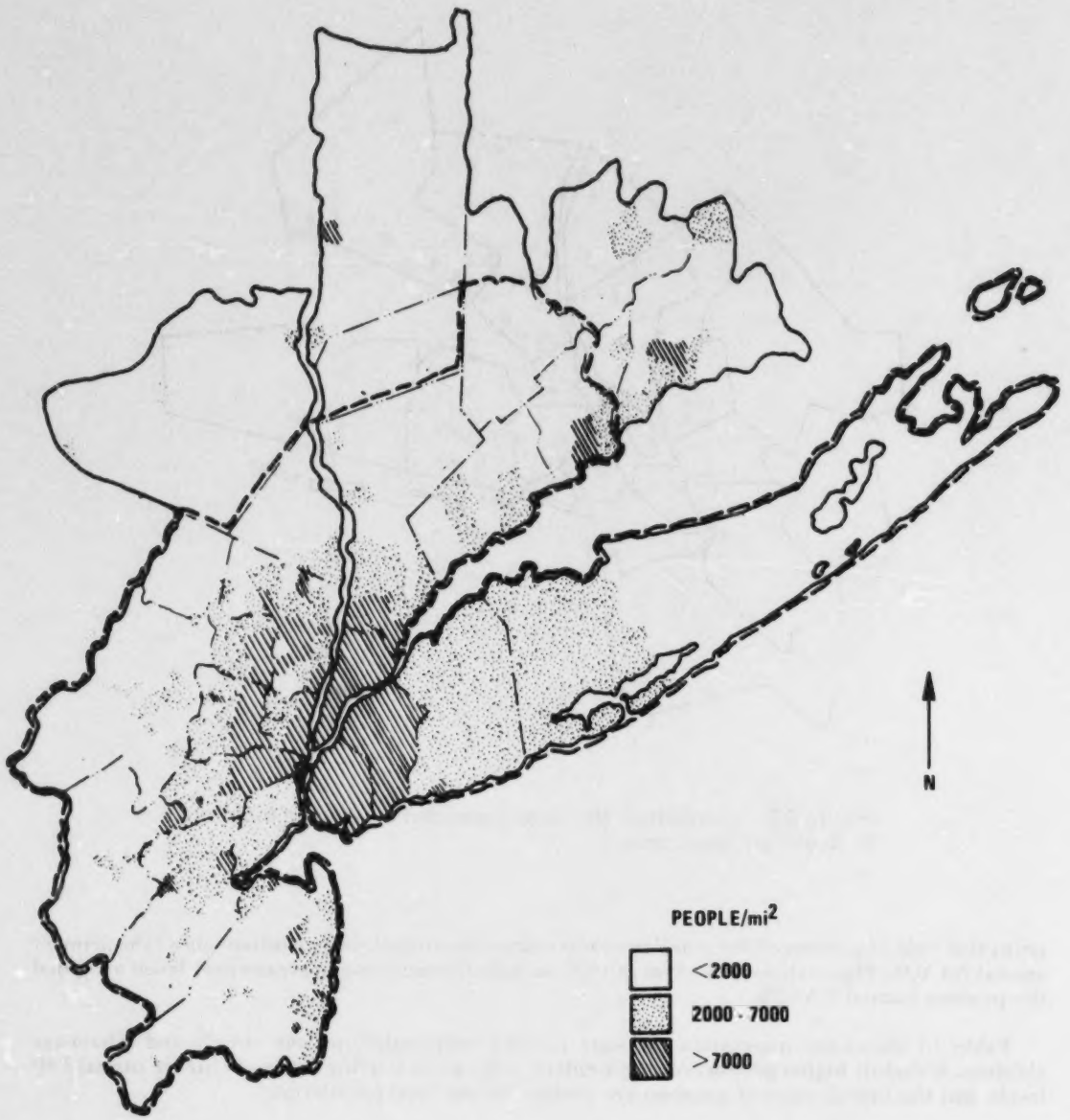

Figure 2-1. Population pattern for New York study area in 1970.

2.1.1.3 Changes in Population Exposed - Trends in population exposure were evaluated in terms of annual averages. These concentration statistics were used to determine the cumulative number of people associated with a particular annual average concentration. These population exposure distributions were then compared for 1970, 1973, and 1976 (Figure 2-5).

The data show that 60 percent of the total population in 1970 was living in areas where annual TSP levels exceeded the primary standard of 75 $\mu g/m^3$. By contrast, in 1973 TSP levels had decreased to the

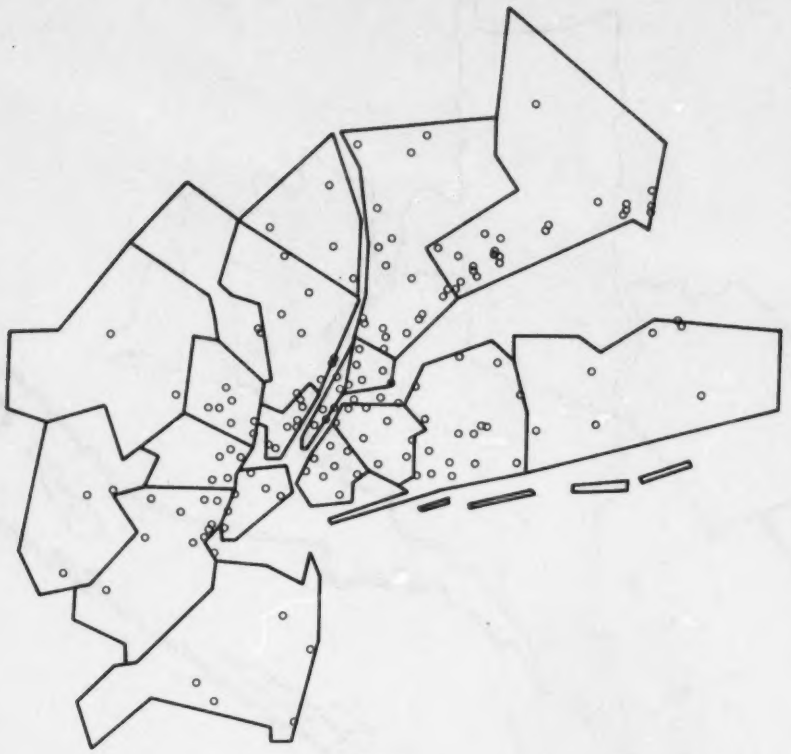

Figure 2-2. Location of 161 total suspended particulate monitors in New York study area.

point that only 12 percent of the population was exposed to annual concentrations above the primary annual NAAQS. The analysis shows that in 1976, no people were living in areas where levels exceeded the primary annual NAAQS.

Table 2-1 shows the population exposure for two subpopulations, the elderly and school-age children. A slightly higher proportion of the elderly population is living in areas of higher annual TSP levels, but the overall rates of progress are similar for the total population.

Typical concentration exposures decreased from 78 $\mu g/m^3$ in 1970, to 61 $\mu g/m^3$ in 1973 and to 55 $\mu g/m^3$ in 1976. This represents an overall improvement of 30 percent in average concentration exposure. An examination of meteorological data indicated that the total annual precipitation in 1973 was 57 inches and in 1976, 41 inches. Since precipitation tends to remove particles from the air and the last year had 28 percent less precipitation, the improvement can be mainly attributed to the success of emission control plans and local economic factors.

2.1.2 Major Decrease in Population Exposed to High Particulate Levels in the City of Chicago

The change in the number of people exposed to total suspended particulate matter in the City of Chicago was examined for the period from 1970 to 1976. The analysis showed an overall reduction in

Figure 2-3. Network of artificial receptor points in New York study area.

average TSP levels of 26 percent. This improvement resulted in 36 percent fewer people being exposed to annual TSP levels above the annual primary health standard of 75 $\mu g/m^3$.

2.1.2.1 Methodology - Air quality data produced by the TSP monitoring network operated by the City of Chicago were examined together with demographic statistics to determine the change in resident population exposed to ambient air pollution of various levels. In 1970, about 3.4 million people were living in Chicago. Population density within the study area is depicted in Figure 2-6. Separate population estimates were used for 1970 and 1975. According to the estimates obtained from the University of Illinois, the study area population exhibited less than a 10 percent decrease during this period. Consequently, the spatial distribution shows little change.

Figure 2-7 presents the locations of 16 TSP monitors that provided the air quality measurements for this analysis. Each monitor produced a valid year of data in 1970 and 1976.

A network of 75 receptor points was used to interface air quality and population data. The receptor points were placed at the center of the "community areas" within the City of Chicago. A community area is an aggregate of adjacent census tracts with similar residential characteristics. Each receptor point represented a subset of the total population, as well as a subset of the less mobile, but susceptible, school-age and elderly populations. The network is displayed in Figure 2-8. The TSP air quality at each receptor point of the network was estimated from the actual monitoring data by spatial interpolation. The estimates of population and air quality were then used to characterize the study area.

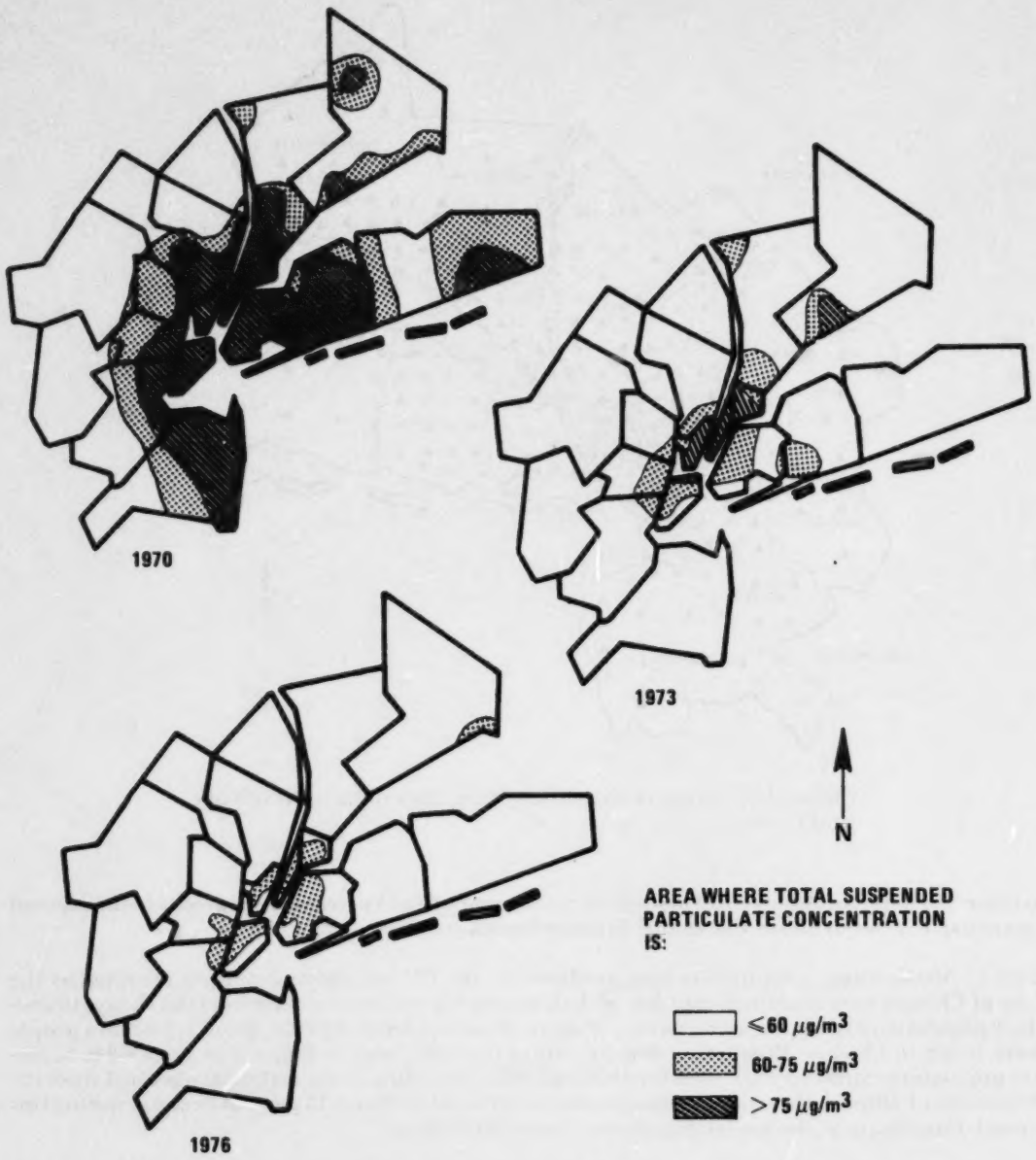

Figure 2-4. Annual geometric mean concentrations of total suspended particulate for 1970, 1973, and 1976 in New York study area.

2.1.2.2 TSP Air Quality Pattern - Isopleths of average TSP during 1970 and 1976 are shown in Figure 2-9. In 1970, the entire city was above the TSP primary NAAQS. The highest TSP concentrations are found in the highly industrialized Calumet region of Southeast Chicago. High concentrations are also found in downtown Chicago, extending westward into the adjoining industrial areas.

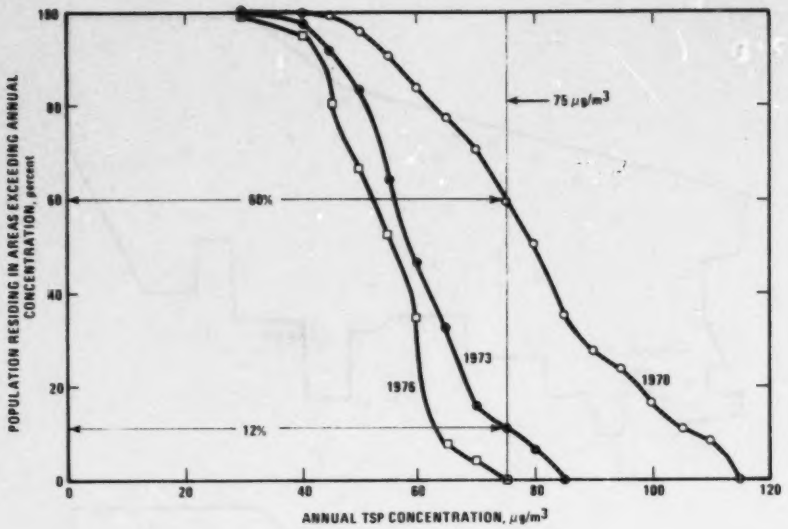

Figure 2-5. Population exposure distributions of annual mean total suspended particulate for 1970, 1973, and 1976 in New York study area.

Table 2-1. NUMBER OF PEOPLE LIVING IN AREAS EXCEEDING NATIONAL AMBIENT AIR QUALITY STANDARD FOR TOTAL SUSPENDED PARTICULATE IN NEW YORK-NEW JERSEY-CONNECTICUT AIR QUALITY CONTROL REGION IN 1970, 1973, AND 1976

Population category	Total population	Percent of category population			Percent reduction between 1970 and 1976
		1970	1973	1976	
Total population	17,000,000	60	12	0	100
School-age	3,900,000	55	10	0	100
Elderly	1,800,000	66	14	0	100

In the 1976 isopleths, a substantial city-wide decrease in TSP levels can be seen. About one-third of the city is now below the primary TSP NAAQS. These areas include the North and South Central parts of Chicago. Both are areas of moderate population density.

2.1.2.3 Changes in Population Exposed - Frequency distributions of population exposure were obtained by comparing the community area population with the corresponding estimates of annual mean TSP. The distributions for 1970 and 1976 are compared in Figure 2-10, which shows that the percent of population residing in Chicago with annual TSP above the primary NAAQS decreased from 100 percent in 1970 to 64 percent in 1976. This represents a 36 percent decrease.

Table 2-2 shows population exposure for two subpopulations, the elderly and school-age children. A slightly higher proportion of the school-age population is living in areas of higher annual TSP levels.

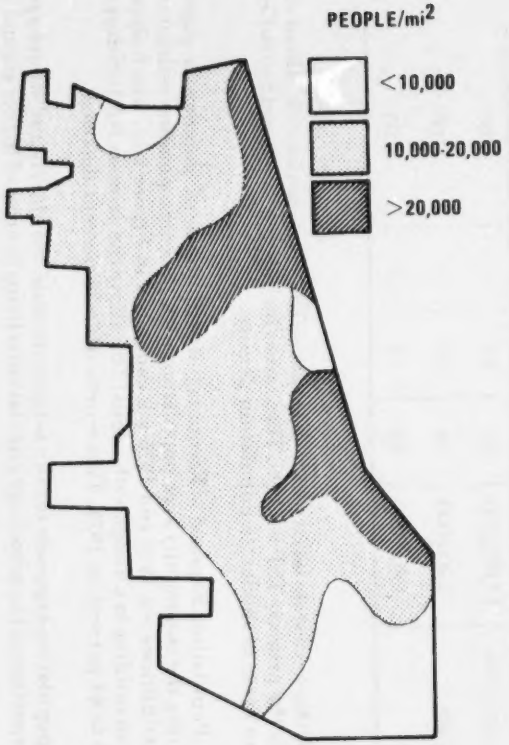

Figure 2-6. Population pattern in 1970 for City of Chicago.

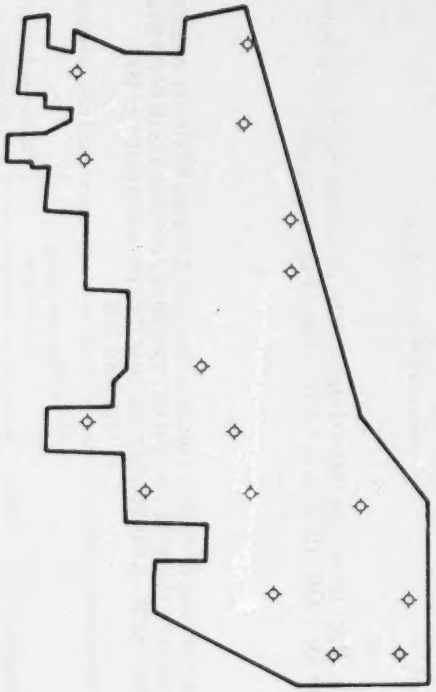

Figure 2-7. Locations of 16 total suspended particulate monitors in City of Chicago.

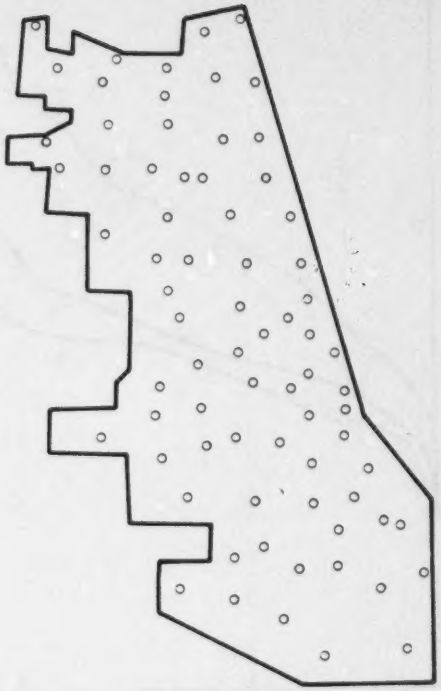

Figure 2-8. Network of receptor points in City of Chicago.

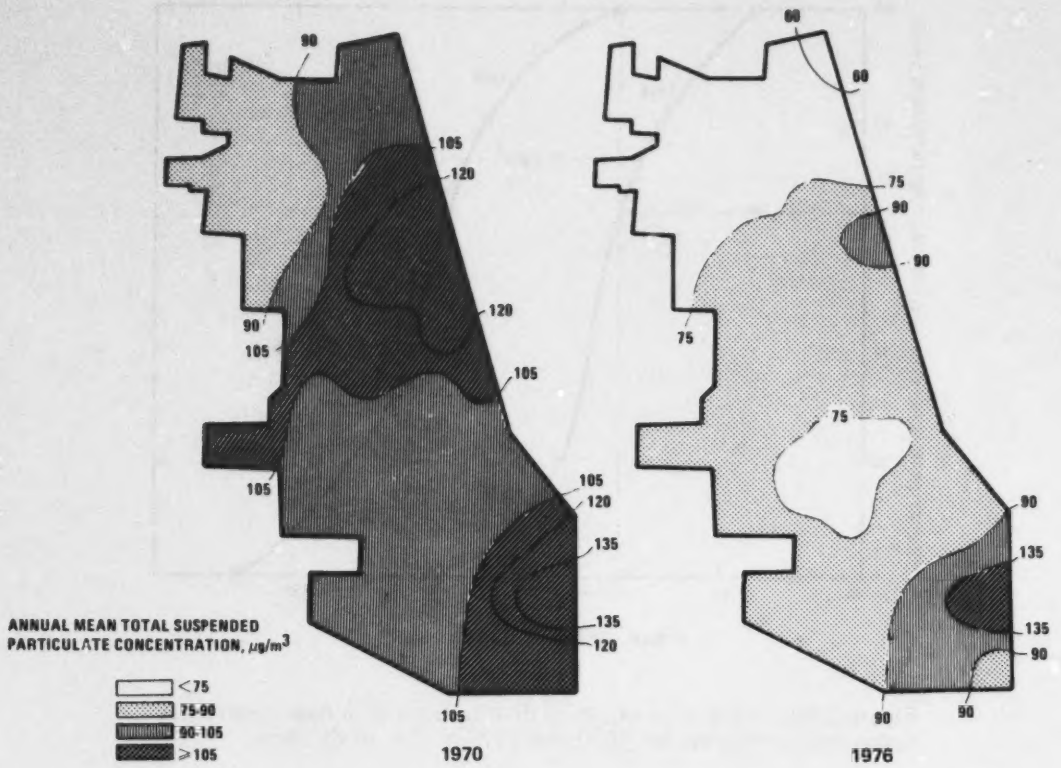

Figure 2-9. Annual mean total suspended particulate in City of Chicago, 1970 and 1976.

Typical exposure decreased from 104 μg/m^3 in 1970 to 77 μg/m^3 in 1976. This represents an overall improvement of 26 percent in average concentration exposure. This improvement is largely due to the success of the emission control efforts.

An examination of meteorological data indicated that total annual precipitation was 46 inches in 1970 and 34 inches in 1976 and that average wind speed was the same for both years. Since precipitation removes particulates from the air and the least polluted year had 26 percent less precipitation, one could reasonably conclude that pollution control efforts were responsible for this improvement.

2.1.3 Decrease in Population Exposed to High Particulate Levels in the Metropolitan Denver Area

The change in the number of people exposed to toal suspended particulate matter in the Metropolitan Denver area was examined for the period from 1970 to 1975. The analysis showed an overall improvement of 10 percent in the exposure to annual average TSP.

The study region, a subset of the Metropolitan Denver Standard Metropolitan Statistical Area (SMSA), consists of Denver County and the populated parts of Adams, Jefferson, and Arapahoe Counties. The study area is shown in Figure 2-11a. The population in the 231 census tracts that

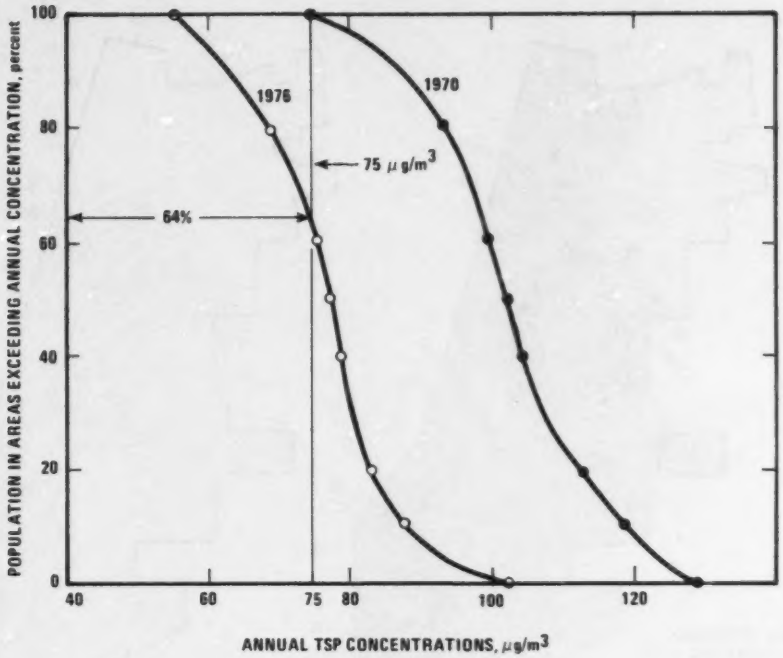

Figure 2-10. Population exposure distributions of annual mean total suspended particulate for 1970 and 1976 in City of Chicago.

Table 2-2. NUMBER OF PEOPLE LIVING IN AREAS EXCEEDING NATIONAL AMBIENT AIR QUALITY STANDARD FOR TOTAL SUSPENDED PARTICULATE IN CHICAGO IN 1970 AND 1976

Population category	Total population	Percent of category population		Percent reduction between 1970 and 1976
		1970	1976	
Total population	3,357,000	100	64	36
School-age	735,000	100	70	30
Elderly	356,000	100	54	46

comprise the study area was 1.06 million in 1970. This represents 86 percent of the people in the Metropolitan Denver SMSA. The spatial distribution of the population density is shown in Figure 2-11b. The study area population increased to 1.27 million in 1975; the growth occurred in suburban areas. Population data for 1970 obtained from the Bureau of the Census were based on total population by census tract. Corresponding estimates for 1975 were obtained from the Denver Regional Council of Governments.

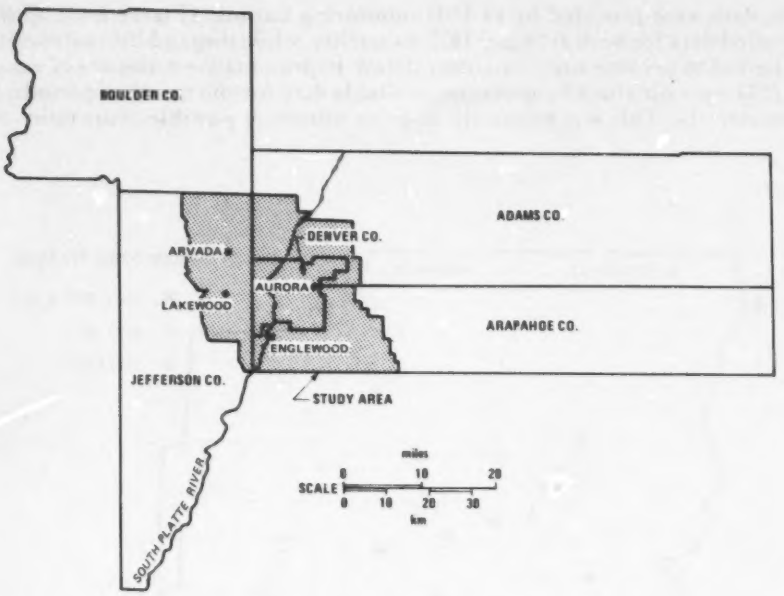

Figure 2-11a. Metropolitan Denver study area.

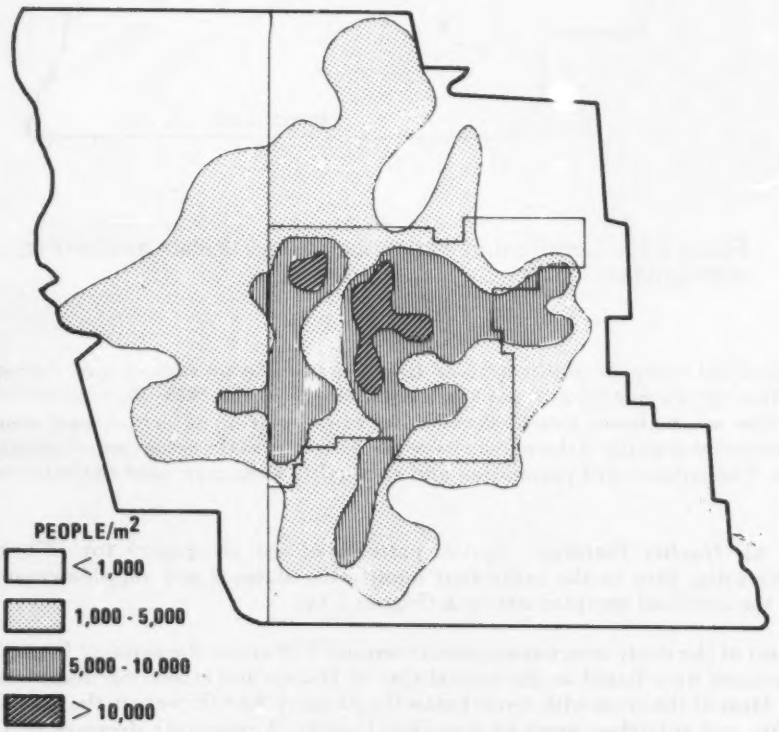

Figure 2-11b. Population density pattern in Metropolitan Denver in 1970.

Air quality data were provided by 19 TSP monitoring stations (Figure 2-12). Thirteen of these monitors provided data for both 1970 and 1975 air quality, while three additional monitors were used in each time period to provide supplementary detail. Representative estimates of annual mean TSP for 1970 and 1975 were obtained by averaging available data for the two time periods: 1969-1971 and 1974-1976, respectively. This was primarily done to minimize possible short-term meteorological effects.

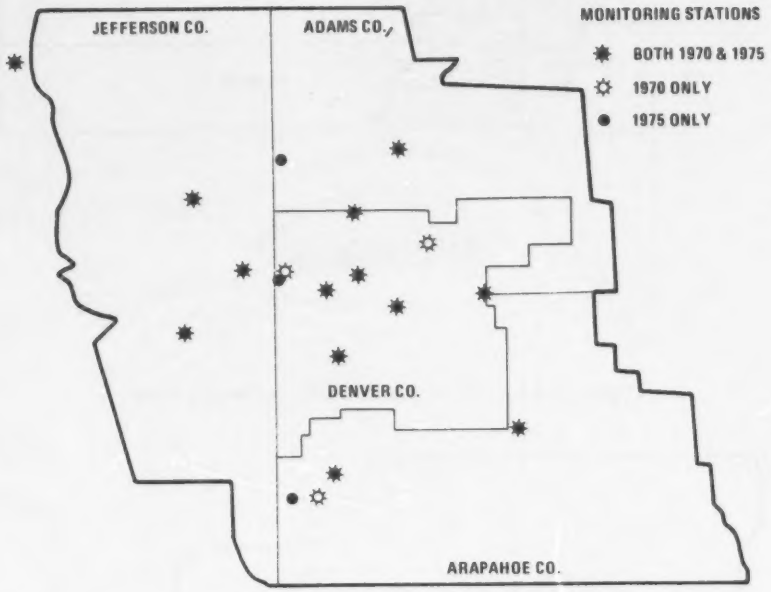

Figure 2-12. Locations of total suspended particulate monitors in Metropolitan Denver.

A network of 231 receptor points derived from the population centroids of the census tract was used to interface the air quality and population data for 1970 and 1975. This network is displayed in Figure 2-13. The census tracts provided estimates of population as well as land area. The TSP air quality at each receptor point of the network was estimated from the actual monitoring data by spatial interpolation. The estimates of population and air quality were then used to characterize the study area.

2.1.3.1 TSP Air Quality Patterns - Spatial patterns of the air quality for 1970 and 1975 were established by using data at the individual monitoring stations and supplementary information estimated at the artificial receptor network (Figure 2-14).

In 1970 most of the study area was exposed to annual TSP above the primary NAAQS. The highest TSP concentrations were found in the central City of Denver and extend northward down the Platte River Valley. Most of the areas with levels below the primary NAAQS were in the southeastern part of Denver County and suburban areas of Arapahoe County. A moderate decrease in TSP levels was observed throughout the region. The areas below the primary NAAQS in 1975 have grown to include more of the eastern portions of Jefferson County.

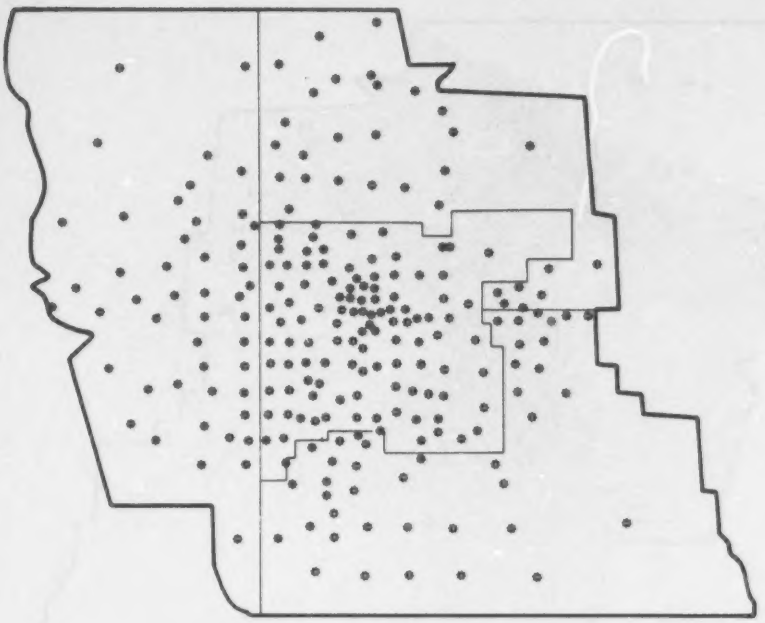

Figure 2-13. Receptor network in Metropolitan Denver area.

2.1.3.2 Changes in Population Exposed - Frequency distributions of population exposure were obtained by comparing the census tract populations with the corresponding estimates of annual mean TSP. The distributions for 1970 and 1975, shown in Figure 2-15, reveal that the percent of population residing in areas with annual TSP above the primary NAAQS decreased from 83 percent in 1970 to 74 percent in 1975. This represents an 11 percent improvement. Typical concentration exposures decreased 10 percent from 96 $\mu g/m^3$ in 1970 to 86 $\mu g/m^3$ in 1975. Both of these indicators show similar improvement to annual TSP in the Metropolitan Denver Area.

2.2 METROPOLITAN LOS ANGELES SHOWS LONG-TERM IMPROVEMENT IN POPULATION EXPOSED TO HIGH PHOTOCHEMICAL LEVELS

Changes in the exposure of the Los Angeles Basin population to photochemical oxidants and nitrogen dioxide were first presented in the *National Air Quality and Emission Trends Report, 1975.*[1] This section updates that analysis through 1976. Air quality data collected from 1965 through 1976 were grouped into 2-year intervals to preserve historical continuity among the trend sites. The analysis showed a considerable reduction in the percent of days the 1-hour primary health standard for oxidants was violated. People in the Los Angeles Basin were exposed to concentrations above the standard on an average of 176 days per year in 1965 and 1966, 144 days per year in 1969 and 1970, 105 days per year in 1973 and 1974, and 112 days per year in 1975 and 1976. The slight degradation between the 1973/1974 period and the 1975/1976 period may be due to an increase in the number of days with poor dispersion.* Analysis of nitrogen dioxide data showed some improvement; people were exposed to a concentration above the 1-hour California welfare standard of 470 $\mu g/m^3$ on an average of 25 days

* A day with poor dispersion is defined as a day with severely restricted mixing, a morning inversion base height of less than 1500 feet, a maximum mixing height of less than or equal to 3500 feet, and a wind speed of less than or equal to 5 mph from 0600 to 1200 PST.

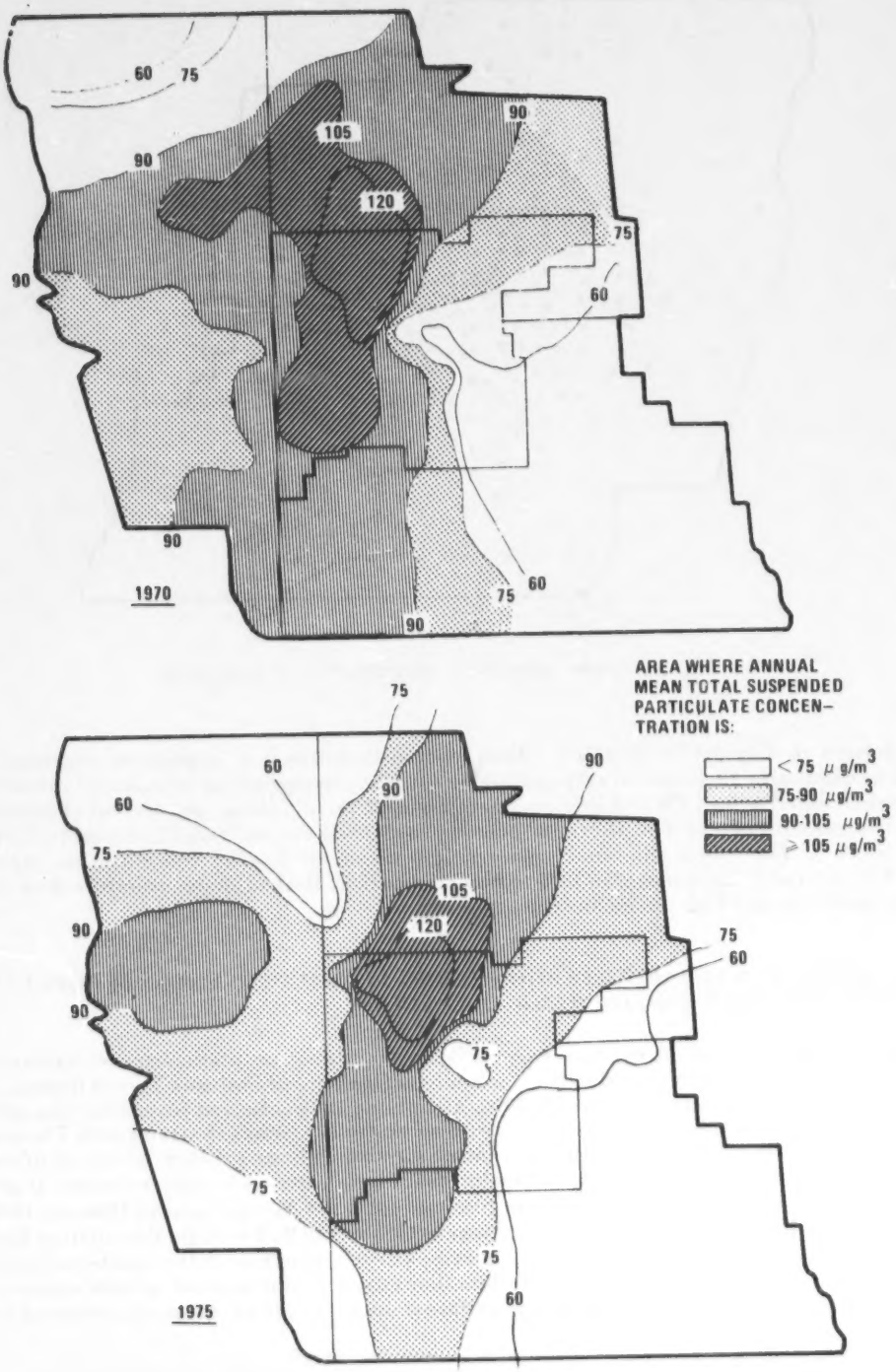

Figure 2-14. Annual mean total suspended particulate in Metropolitan Denver, 1970 and 1975.

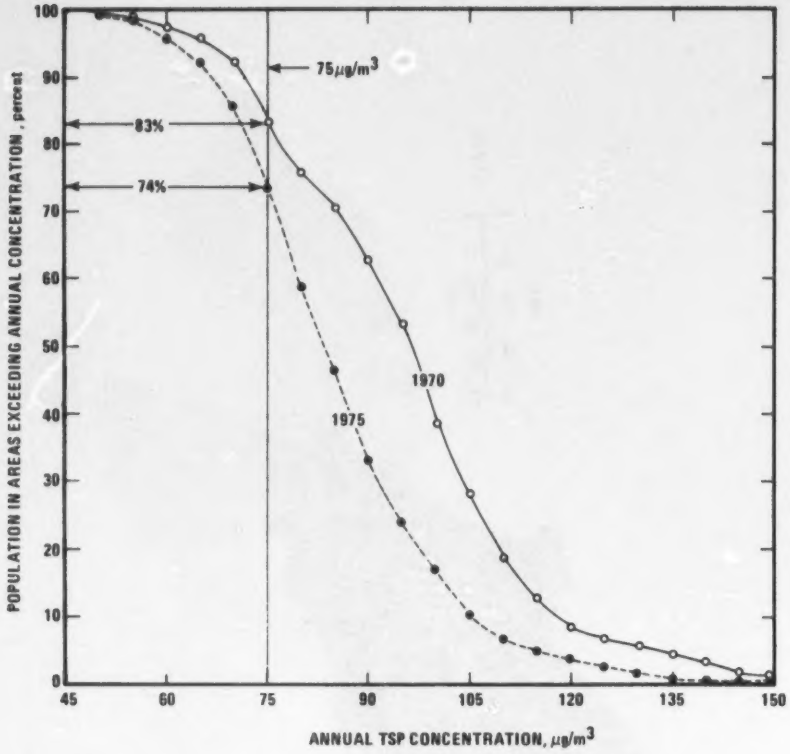

Figure 2-15. Population exposure distributions of annual total suspended particulate for 1970 and 1975 in Metropolitan Denver.

per year in 1965 and 1966, 27 days per year in 1969 and 1970, and 19 days per year in 1975 and 1976. Although the California standard is related to visibility, it served as a convenient reference point to evaluate population exposure to hourly concentrations of nitrogen dioxide.

2.2.1 Methodology

Air Quality data collected at ten air monitoring stations measuring oxidants and eight measuring nitrogen dioxide were examined together with population statistics prepared by the Southern California Association of Governments (SCAG) and with the 1970 census data. A population of 7.9 million was associated with the oxidant monitoring data, and the nitrogen dioxide monitoring network was judged to represent 6.5 million people. Figure 2-16 depicts the spatial variation of the population density over the study area. Figure 2-17 presents the location of the ten monitoring sites that provided the air quality data for the analysis.

The air quality and population data were interfaced by using a standardized network of 57 receptor points for the oxidant analysis and 45 receptor points for the nitrogen dioxide analysis (Figure 2-18). The standardized network provides complete area coverage, but more detail is given to areas of high population density. Each standard network point thus represents a local population as well as its air quality. The oxidant and nitrogen dioxide air quality of each grid point of the standardized network was estimated from the actual monitoring data by spatial interpolation. The estimates of population and air quality were then used to characterize the region.

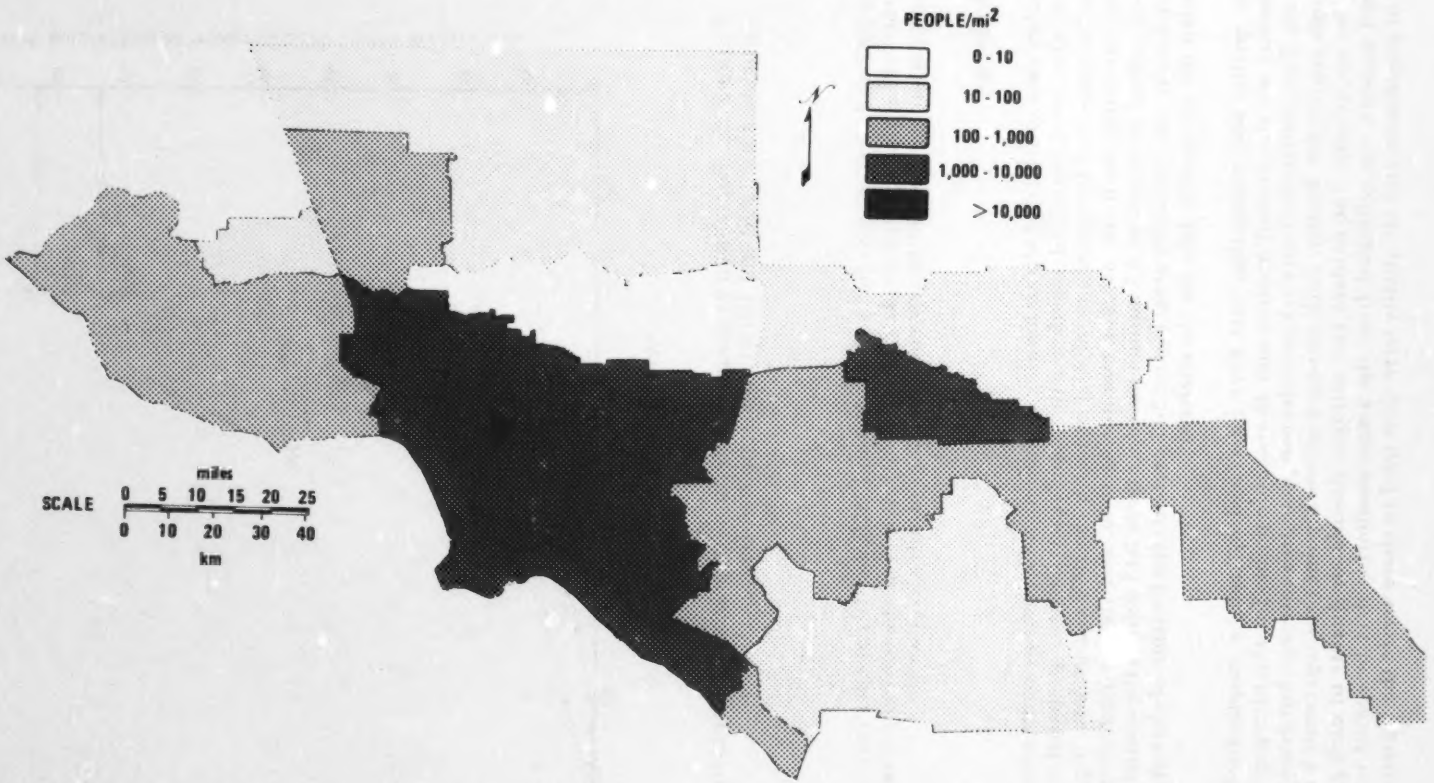

Figure 2-16. Population density of Los Angeles Air Basin in 1970.

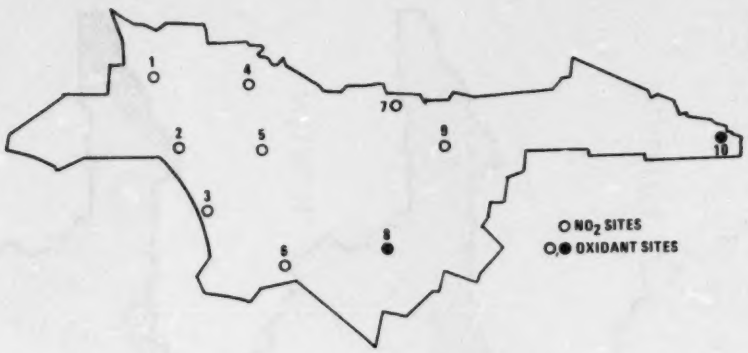

Figure 2-17. Locations of nitrogen dioxide and oxidant trend sites in Los Angeles air basin.

Figure 2-18. Standard demographic network for trend analysis in Los Angeles air basin.

2.2.2 Changes in Population Exposed to Oxidants

Daily exposure patterns are displayed on isopleth maps to indicate areas of the region that exceed the 1-hour oxidant standard of 160 $\mu g/m^3$ for a given percent of the days (Figure 2-19). A long-term improvement can be seen over the 12-year period from 1965 through 1976. In 1965 and 1966, more than half of the Los Angeles Basin violated the standard more than 50 percent of the days and the rest of the region, at least 20 percent of the days. The greatest overall improvement was in 1973 and 1974 when the standard was violated more than 50 percent of the days only in a small area around Azusa. In 1975 and 1976, areas around Burbank and San Bernardino also violated the standard more than 50 percent of the days. These same areas violated the standard in excess of 45 percent of the days in 1973 and 1974. An examination of days with poor dispersion shows an increase in the 1975/1976 period over the 1973/1974 period (Table 2-3). This, in part, explains the slight deterioration in oxidant air quality between the two time periods.

The region-wide trends in population exposure to oxidant are summarized in Table 2-3. People in the study region were exposed to concentrations above the standard on an average of 176 days per year during 1965 and 1966, 144 days per year in 1969 and 1970, 105 days per year in 1973 and 1974, and 112 days in 1975 and 1976. The trends are similar for values greater than twice the standard. Of interest is the lack of oxidant improvement between 1971 and 1976. When the three, 2-year periods are compared, the average number of days on which the oxidant standard was violated correlates well with the average number of days with poor dispersion. This suggests that changes in the number of days on which the oxidant NAAQS was violated over the 1971-1976 period may be due to meteorology.

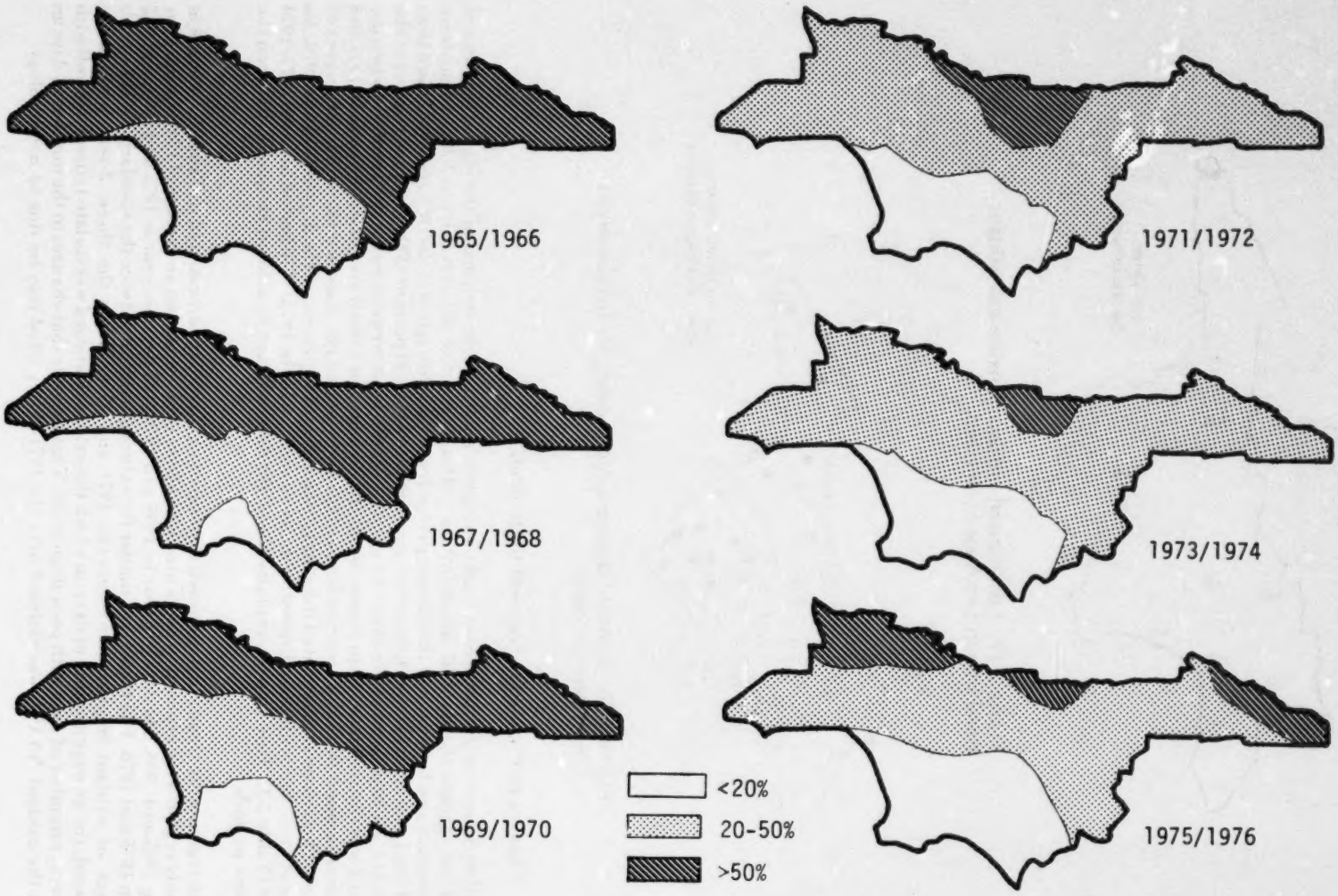

Figure 2-19. Percent of days on which NAAQS for oxidant was exceeded during six 2-year periods in Metropolitan Los Angeles.

Table 2-3. COMPARISON OF AVERAGE NUMBER OF DAYS WITH POOR DISPERSION[a] AND AVERAGE NUMBER OF DAYS VIOLATING NAAQS FOR OXIDANTS

Index	1965 and 1966	1967 and 1968	1969 and 1970	1971 and 1972	1973 and 1974	1975 and 1976
Average No. of days per year with poor dispersion	94.5	98.5	95.5	78.5	65.5	86.5
Average No. of days per year exceeding 160 $\mu g/m^3$	176	162	144	109	105	112

[a]A day with poor dispersion is defined by the Los Angeles Air Pollution Control District as a "Rule 57 day." These days have severely restricted mixing, a morning inversion base height of less than 1500 feet, a maximum mixing height of less than or equal to 3500 feet, and a wind speed of less than or equal to 5 miles per hour from 0600 to 1200 PST.

2.2.3 Changes in Population Exposed to Nitrogen Dioxide

The National Air Quality and Emissions Trends Report, 1975[1] reported that much of the study region violated the annual average primary NAAQS of 100 $\mu g/m^3$ throughout the 10-year period, 1965-1974. This was also true in 1975 and 1976.

This report focuses on the percent of days the 1-hour California "welfare" standard of 470 $\mu g/m^3$ was violated (Figure 2-20). A major question is "Why didn't the improvement in NO_2 from 1971/1972 to 1973/1974 continue into 1975/1976?" Table 2-4 compares the average number of days with poor dispersion versus the average number of days per year exceeding the 1-hour California standard. Although 1975/1976 had a typical number of poor dispersion days, when compared with earlier years, days with poor dispersion were significantly higher in 1975/1976 than in 1973/1974. The lack of NO_2 improvement from 1973/1974 to 1975/1976 could be due to meteorology coming back to normal in 1975/1976 after unusually good conditions in 1973/1974. The relatively more severe meteorological condition of 1975/1976 may have disguised the effect of NO_2 emission reductions that took place between 1973/1974 and 1975/1976.

The effect of the long-term nitrogen oxide control strategy may also have been temporarily distorted by the gasoline crisis in the winter of 1973/1974. Not only was meteorology unusually good in 1973/1974 but also NO_2 air quality in 1973/1974 benefited slightly from the gasoline shortage. A fairer test of recent NO_2 trends would be to compare 1975/1976 with 1971/1972; in this case, we see improvement in both the isopleths maps and the average number of days violating the California welfare standard—33 days in 1971 and 1972 versus 19 days in 1975 and 1976.

2.3 ACKNOWLEDGMENT

The Monitoring and Data Analysis Division would like to recognize the contributions of Neil Frank, William F. Hunt, Jr., Jim Capel, and Margaret Swann of the Division in assembling this section. The section would not have been possible without support received from EPA Regional Offices. Specifically, the Division would like to recognize Lew Heckman, Region II; Stephen Goranson and Linda Larson, Region V; Barry Levene, Region VIII; and Coe Owen, Region IX.

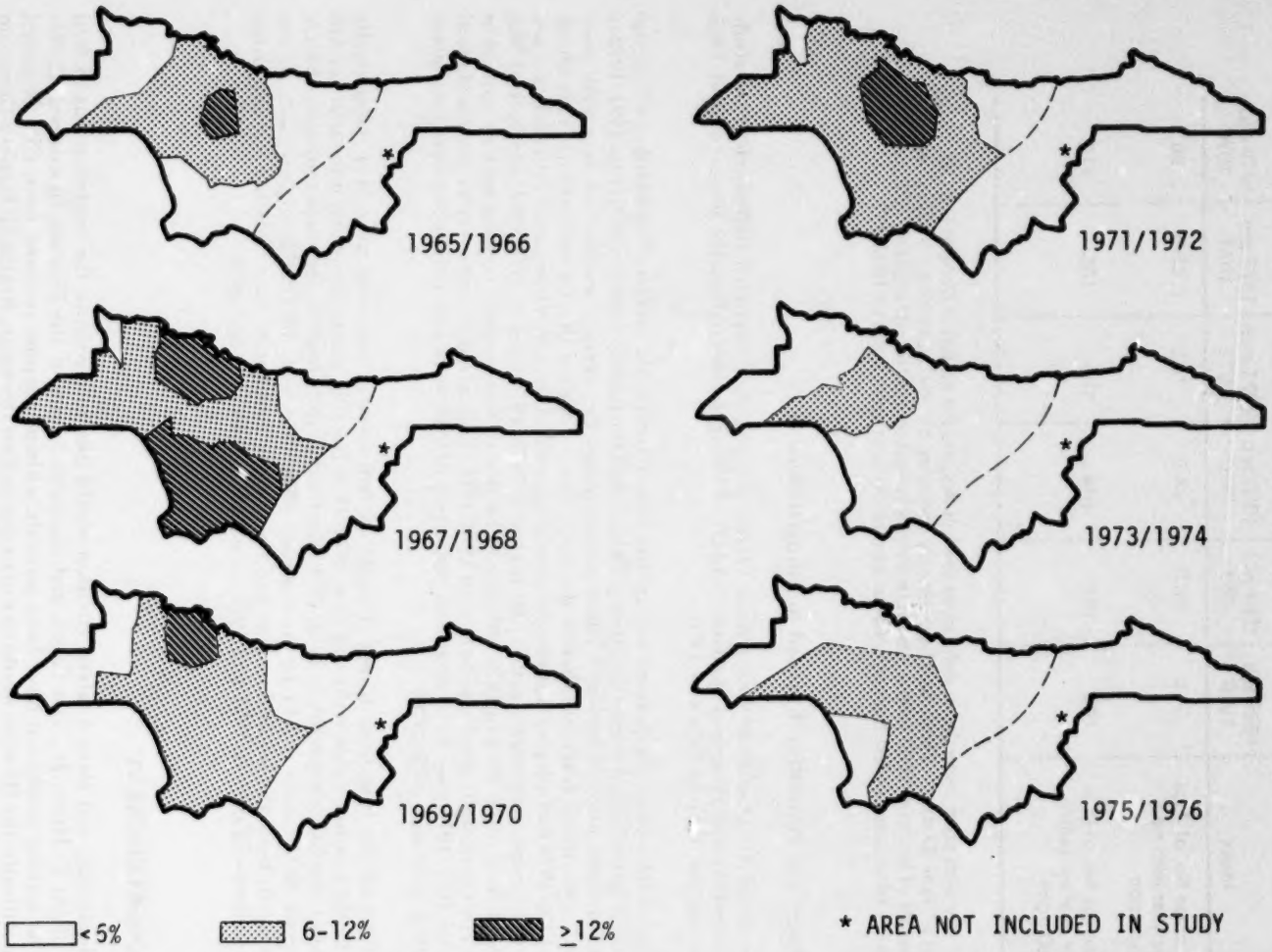

Figure 2-20. Percent of days on which California 1-hour standard was exceeded during six 2-year periods in Metropolitan Los Angeles.

Table 2-4. COMPARISON OF AVERAGE NUMBER OF DAYS WITH POOR DISPERSION[a] AND AVERAGE NUMBER OF DAYS VIOLATING CALIFORNIA 1-hour WELFARE STANDARD FOR NITROGEN DIOXIDE

Index	1965 and 1966	1967 and 1968	1969 and 1970	1971 and 1972	1973 and 1974	1975 and 1976
Average No. of days per year with poor dispersion	94.5	98.5	95.5	78.5	65.5	86.5
Average No. of days per year exceeding the California 1-hour standard (470 $\mu g/m^3$)	25	40	27	33	18	19

[a]A day with poor dispersion is defined by the Los Angeles Air Pollution Control District as a "Rule 57 day." These represent days with severely restricted mixing, a morning inversion base height of less than 1500 feet, a maximum mixing height of less than or equal to 3500 feet, and a 0600-1200 Pacific Standard Time wind speed of less than or equal to 5 miles per hour.

2.4 REFERENCES FOR SECTION 2

1. *National Air Quality and Emissions Trends Report, 1975.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. Publication No. EPA-450/1-76-002. November 1976.

2. Horie, Yugi and Arthur C. Stern. *Analysis of Population Exposure to Air Pollution in New York-New Jersey-Connecticut Tri-State Region.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, N.C. Publication No. EPA-450/3-76-027. March 1976.

3. NATIONAL AND REGIONAL TRENDS IN CRITERIA POLLUTANTS

Trends in ambient levels of total suspended particulate, sulfur dioxide, carbon monoxide, oxidants, and nitrogen dioxide are reported in this section. Each of these criteria pollutants is discussed individually; the extent of the analysis varies according to the amount of available historical data. In contrast to Section 2, which dealt with specific urban areas, this section focuses upon national trends and trends over broad geographic regions. (Section 4 of this report presents maps illustrating the concentration ranges of several pollutants in various parts of the country.)

Considerable thought has been given to various ways to improve the nation's ambient air quality monitoring programs. The recent activities of the Standing Air Monitoring Work Group (SAMWG) have served as a focal point for new ideas. This work group, composed of representatives from EPA and State and local air monitoring agencies, has developed a comprehensive strategy document for ambient air quality monitoring.[1] Because many elements of the SAMWG strategy document will affect future trend analyses, some of these points are mentioned here so that interested readers will be made aware of anticipated improvements in the nation's air monitoring programs.

The most obvious change will be the designation of specific National Air Quality Stations (NAQTS) for the criteria pollutants. These NAQTS sites would primarily be determined by the population of the area. For total suspended particulate and sulfur dioxide, the allocation would be on the basis of population and pollutant concentration. Selected for the primary purpose of long-term trends analyses, these measuring stations will provide more consistent data bases from one year to the next and also ensure adequate geographical coverage. Obviously, these NAQTS sites would not be the only component of an air monitoring program. There are a variety of purposes for ambient monitoring programs, and, therefore, it will be necessary to supplement these NAQTS sites with other types of monitoring stations. Other items of note in the SAMWG strategy document relate to quality assurance, increased continuous monitoring, and adherence to standardized siting criteria, all of which will improve the ambient air quality data bases and thereby serve to improve subsequent trend analyses. Readers interested in the details of the SAMWG recommendations are referred to the strategy document.

3.1 TRENDS IN TOTAL SUSPENDED PARTICULATE

The general long-term improvement in ambient air quality with respect to total suspended particulate (TSP) has been discussed in previous reports.[2-6] During the 1970's, there has been nationwide improvement in TSP concentrations, but many areas experienced increases between 1975 and 1976. This section discusses national and regional TSP trends during the 1970-1976 time period with particular attention given to comparisons between 1975 and 1976.

The data used in these analyses were obtained from EPA's National Aerometric Data Bank. The vast majority of the data were collected by State and local agencies through their air monitoring programs and then submitted to EPA. All sites having four consecutive quarters of data from 1970-1973 and also from 1974 through 1976 were included in these analyses. This selection criterion was used to ensure balanced seasonality and a comparable data base from the beginning to the end of the time period. Sufficient data to satisfy this selection criterion were available from 2,350 sites. Although a site would need only a minimum of 2 years of data to qualify for selection, 70 percent of these 2,350 sites had at least 4 complete years of data during the 1970-1976 time period.

As in last year's Trends Report,[6] a modified version of the graphical technique known as a box-plot[7] is used to display trends. This plotting technique depicts several characteristics of the data simultaneously. Figure 3-1 is a sample illustration of the plotting conventions used for the box-plots in

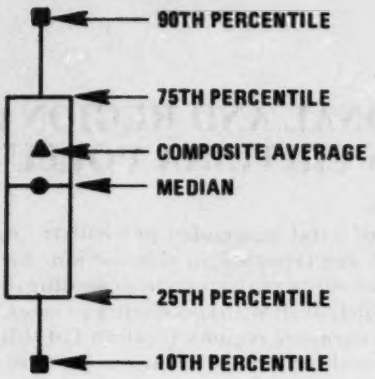

Figure 3-1. Sample illustration of plotting conventions for box plots.

this report. For each year, various percentiles and the composite averages are indicated so that the general trend in the average levels may be seen as well as the trends for the higher and lower concentration ranges.

3.1.1 Long-Term TSP Trends: 1970-1976

During the 1970's, there has been general improvement nationally in ambient TSP concentrations. Figure 3-2 shows a box-plot presentation of trends in geometric mean TSP levels during the 1970-1976 time period for the 2,350 sites used in this analysis. This plot is consistent with results discussed in previous reports.[2-6] The general pattern shows stability for the lower concentration sites and more pronounced improvement for the higher concentration ranges. The median and composite average also indicate fairly consistent improvement through 1975. During this time period, the overall rate of improvement was slightly less than 4 percent per year, with more marked improvement in the Northeast and Great Lakes regions. Figure 3-3 displays trends in peak values at these same sites and shows a similar pattern during this time period. It should be noted that sampling frequencies at many of these sites were increased during this time period. While increasing sampling frequencies would not alter trends in annual means, it could be expected to result in an artificial increase on the order of 2 to 3 percent per year for the peak values during this time period. Even with this contribution, however, the general pattern in Figure 3-3 shows improvement through 1975. Also apparent in both graphs is the trend reversal in 1976, which is discussed in more detail in the following section dealing with short-term changes. Knowledge of geographical differences in long-term TSP trends provides background information that is useful in considering the short-term changes.

Figure 3-4 displays 1970-1976 trends for each EPA Region and provides a convenient presentation of trends by geographical area. Although all areas had improved TSP levels in the 1970-1976 time period, trends in the western areas of the country were generally less pronounced. In many cases, this geographical variation is attributable to a difference in the nature of TSP problems from one area to another. In some locations, wind-blown dust is an important component of TSP levels and is more difficult to control than emissions from traditional sources.

As would be expected from these graphs, improvement was fairly consistent from 1970 to 1976, with 72 percent of the sites having decreases in ambient TSP levels. Because air pollution control strategies are designed to reduce levels at locations exceeding the National Ambient Air Quality Standards, more pronounced improvement would be expected for the sites with higher concentrations. For those sites with 1970-1973 averages above the annual primary standard, 81 percent showed improvement. For sites in this category, improvements outnumbered increases by at least a 2 to 1 margin in all

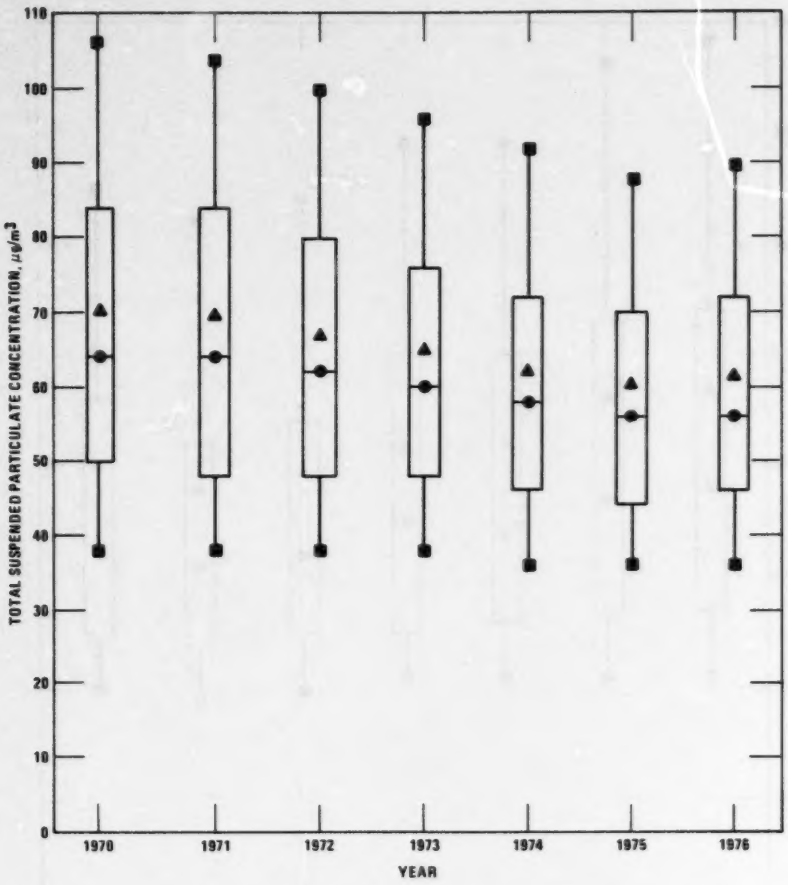

Figure 3-2. Trends of annual mean total suspended particulate concentrations from 1970 to 1976 at 2,350 sampling sites.

regions of the country. Using nonparametric regression, 27 percent of these higher concentration sites show statistically significant improvement while only 1 percent of these sites had statistically significant increases.

3.1.2 Short-Term TSP Trends: 1975-1976

In many areas of the country, the general downward trend in TSP levels in the early 1970's was followed by a reversal in 1976. This was apparent in Figure 3-2 and 3-3 for the nation, but is more obvious in some of the regional graphs in Figure 3-4. Based upon changes between comparable quarters in 1975 and 1976 for these TSP trend sites, 53 percent of those comparisons showed increases. Over half the States had more increases than decreases between 1975 and 1976. The Southeast, Midwest, and West generally recorded increases.

The widespread pattern of these increases suggests that some common factor was involved. Because no general increases in particulate emissions throughout these areas occurred in 1976 and there were

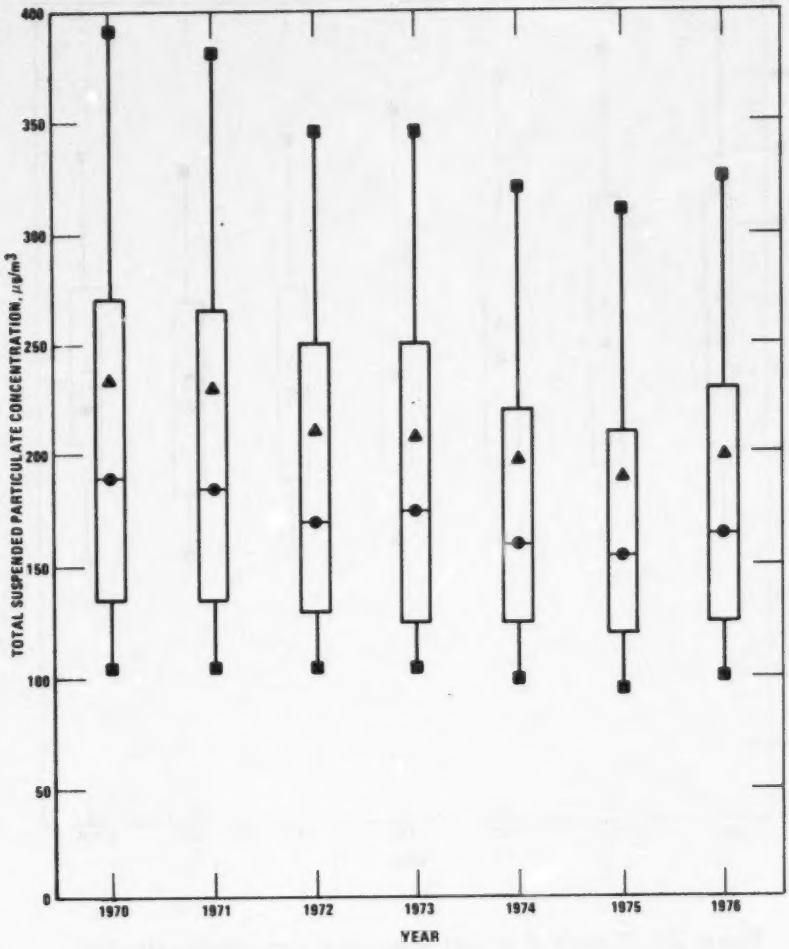

Figure 3-3. Trends of peak daily total suspended particulate concentrations from 1970 to 1976 at 2,350 sampling sites.

not widespread changes in sampling methodology, meteorological conditions would be the likely candidate for explaining these increases. In fact, many State agencies ranging from the Midwest to Washington and California have cited meteorology as the main reason for these TSP increases in 1976.[8-14] Large areas of the country experienced drought during 1976, and these extremely dry soil conditions increased the likelihood of wind-blown dust contributing to ambient TSP levels.

Figure 3-5 illustrates the geographical areas affected by drought in 1976. This map was constructed by integrating the Palmer Index* throughout 1976. The Palmer Index, a reasonable indicator of overall soil moisture conditions, reflects both rainfall and evapotranspiration. This map shows that dry soil conditions existed in those general areas that had TSP increases. Specific days that had high TSP concentrations may also be examined to see whether the dry conditions contributed to these values.

* Obtained from the *Weekly Weather and Crop Bulletin*, 1976.

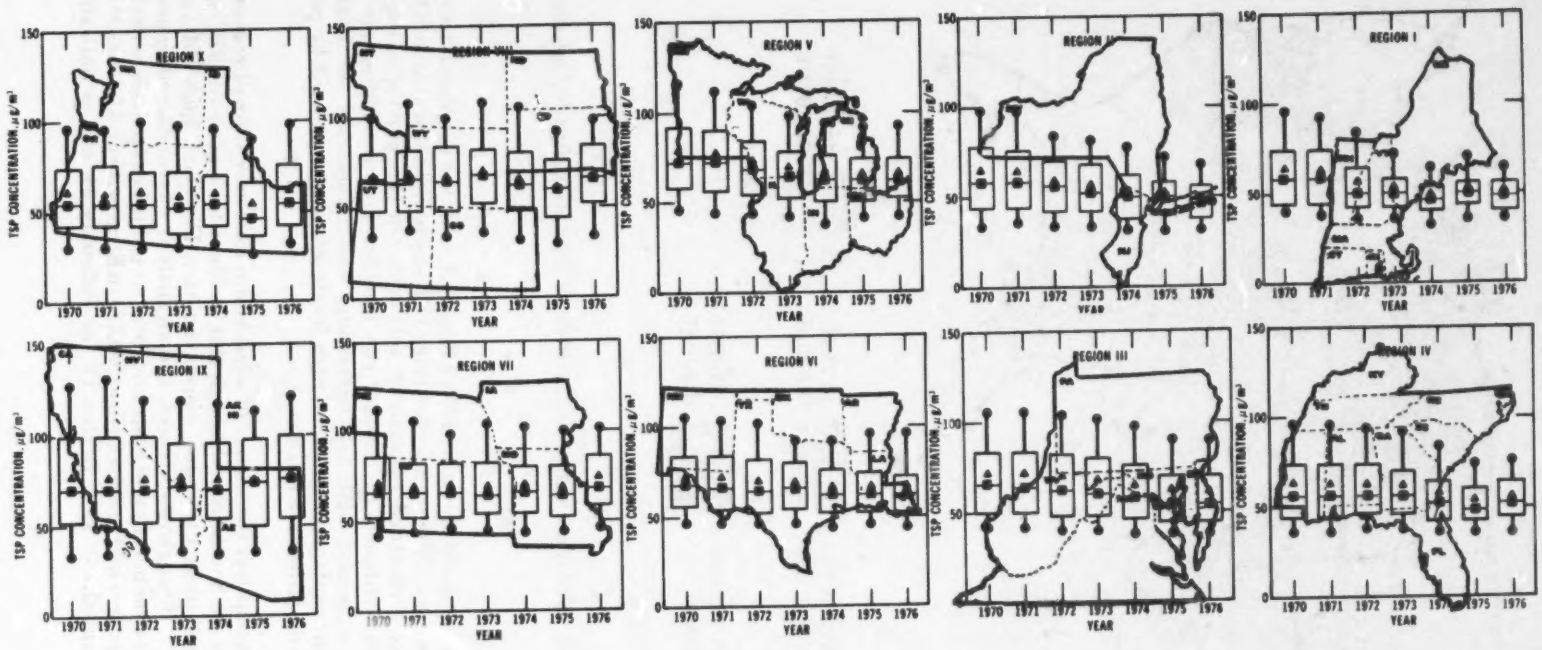

Figure 3-4. Regional trends of annual mean total suspended particulate concentrations, 1970 - 1976.

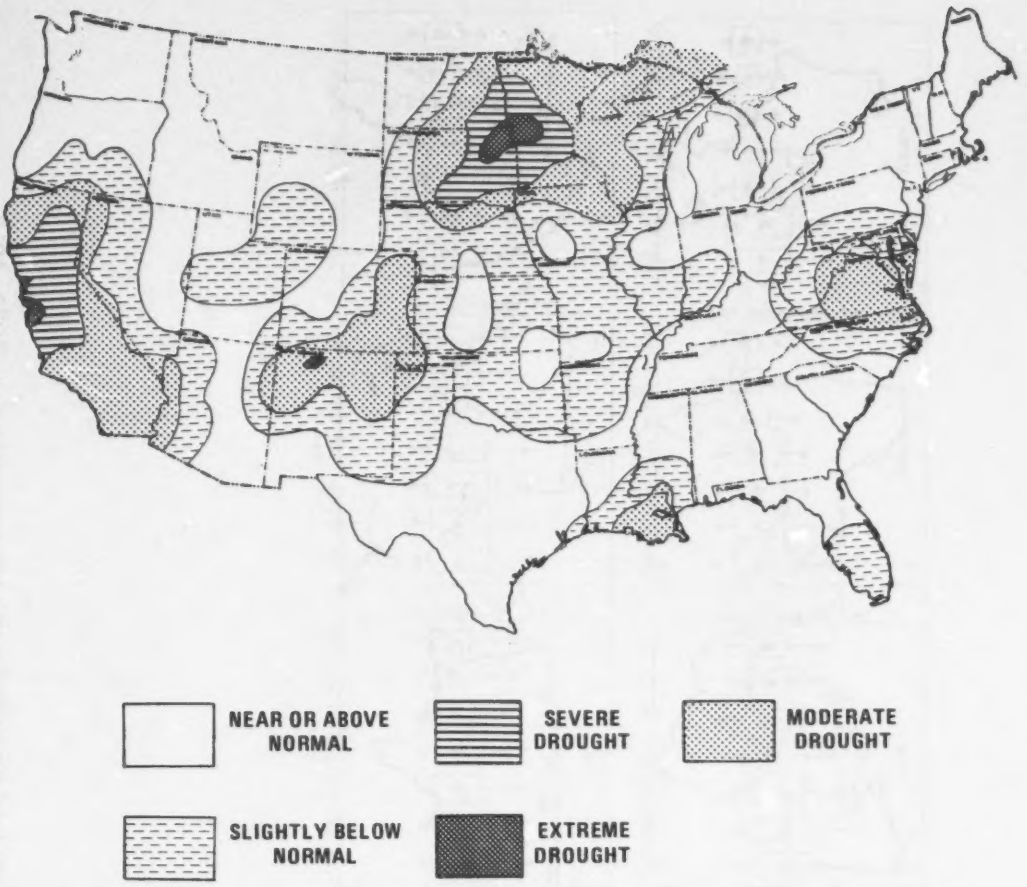

Figure 3-5. Index of drought from monthly Palmer Indices for period April - October 1976.

Such an analysis was done in the Midwest by EPA's Region V with the cooperation of the State agencies in Region V and also Iowa.[15] Figure 3-6 illustrates TSP isopleths in this area for October 15, 1976. Elevated TSP levels were recorded throughout this area. On this particular day, dry soil conditions and strong winds combined to increase the likelihood of wind-blown dust. These meteorological factors also coincided with fall harvesting, which increased the likelihood of wind-blown soil particles. This explanation of these high levels was also supported by microscopic examination of the high-volume filters for this day.[15]

An even more dramatic example of the impact of wind-blown dust over a broad geographic area occurred in February 1977 in the Southeast. Although this incident took place in 1977 rather than 1976, it illustrates the potential impact that dust storms can have. Extremely high TSP values were recorded on February 24, 1977, throughout this area, and an analysis was conducted by personnel of EPA's Region IV office with the cooperation of State and local air pollution agencies in the Southeast as well as the National Weather Service Forecast Office (NOAA) in Birmingham, Alabama.[16] Figure 3-7 shows TSP concentration isopleths in EPA Region IV for February 24, and is indicative of the

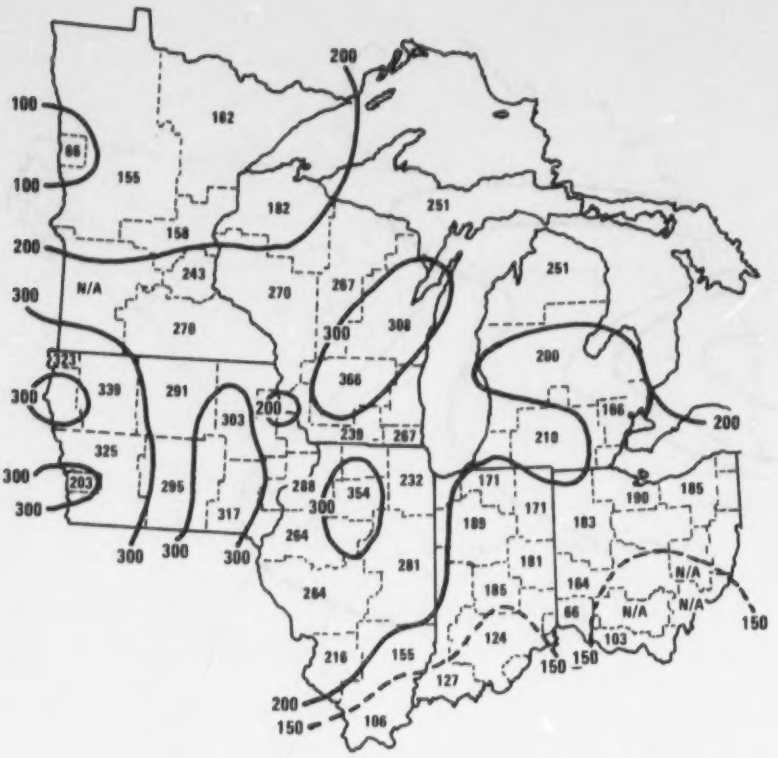

Figure 3-6. Isopleths of total suspended particulate concentrations ($\mu g/m^3$) in EPA Region V and Iowa for October 15, 1976.

extremely high values in this area for that day. The basic cause was wind erosion of the soil. Figure 3-8 graphically depicts a satellite view of the dust storm at successive points in time from February 23-25, 1977. Extremely dry soil conditions in the Central Plains and the development of a strong frontal system resulted in dust being stirred up and eventually transported east. Meteorological conditions that were likely to cause dust storms coincided with widespread cultivation for farming, and the end result was widespread transport of wind-blown dust throughout a broad geographical area. It should be noted that the concentration levels reported during this storm were extremely unusual for this area and represent historically high values that are not at all typical of the normal TSP ranges in the region.

In discussing the 1975-1976 increases, it should be noted that some areas continued to improve in 1976. For example, the continued progress in the New York area was presented in Section 2. Nationally, for those trend sites with complete 1975 and 1976 data, 54 percent of the sites above the primary standard in 1975 showed improvement in 1976. In general, the short-term 1975-1976 increases did not appreciably affect status with respect to the primary standards. For those sites located in highly populated areas (SMSA's), 5 percent went from above 75 $\mu g/m^3$ (the primary standard) to below, while another 5 percent crossed in the opposite direction for a net change of zero. For those sites located outside these populated areas, however, 8 percent crossed in the increasing direction while only 3 percent dropped below the standard so that there was a net increase. This seems consistent with the meteorological contribution to these increases in that the urbanized areas showed a lesser impact

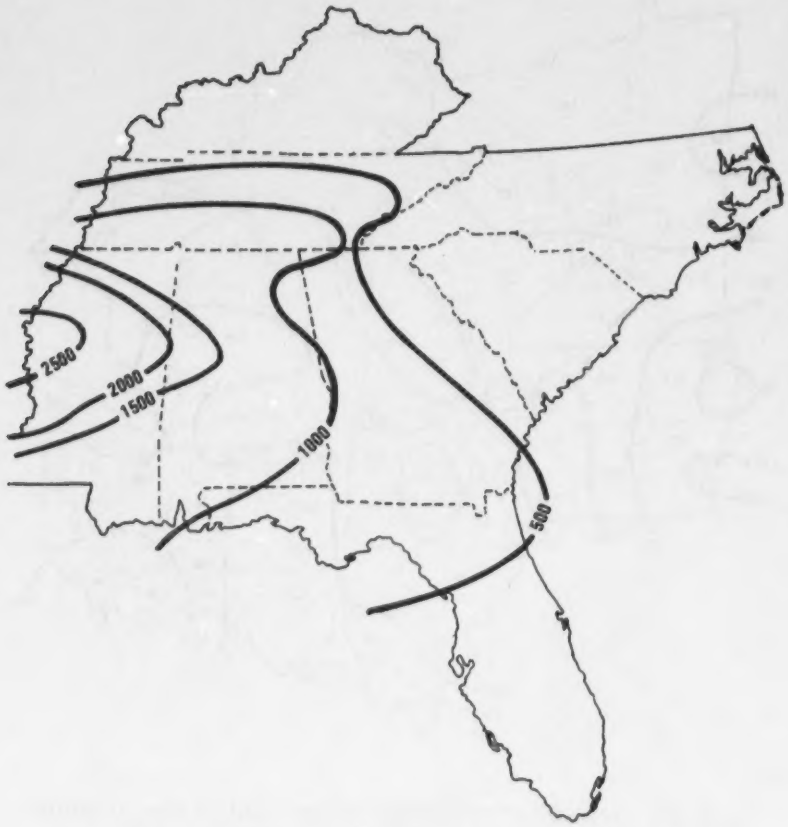

Figure 3-7. Isopleths of total suspended particulate concentrations ($\mu g/m^3$) in Southeast for February 24, 1977.

3.2 TRENDS IN SULFUR DIOXIDE

The entire sulfur dioxide picture has changed in the 1970's. The early 1970's saw dramatic decreases in ambient sulfur dioxide levels in the nation's urbanized areas.[2-6] Since then the national trends have been much more stable, and violations of the sulfur dioxide standard are generally confined to areas around specific sulfur oxide sources.

Sites for this analysis were obtained using the same selection criteria discussed in Section 3.1 for TSP. For sulfur dioxide, 722 sites had sufficient historical data to qualify as sulfur dioxide trend sites. Less than 10 percent of these sites had data in 1970-1971, when sulfur dioxide levels were rapidly reduced in many areas; therefore, graphs are presented only for the 1972-1976 time period. All data were used when examining changes, however. Those readers interested in the earlier time period are referred to previous reports.[2-6]

Figure 3-9 displays a box-plot of nationwide sulfur dioxide trends for annual means. The graph shows general improvement with relatively stable behavior in the low to middle ranges. In discussing changes in ambient sulfur dioxide levels, it is useful to consider sites with annual averages of less than 26 $\mu g/m^3$ (0.01 ppm) as a separate category. These sites have annual means less than one-third of the

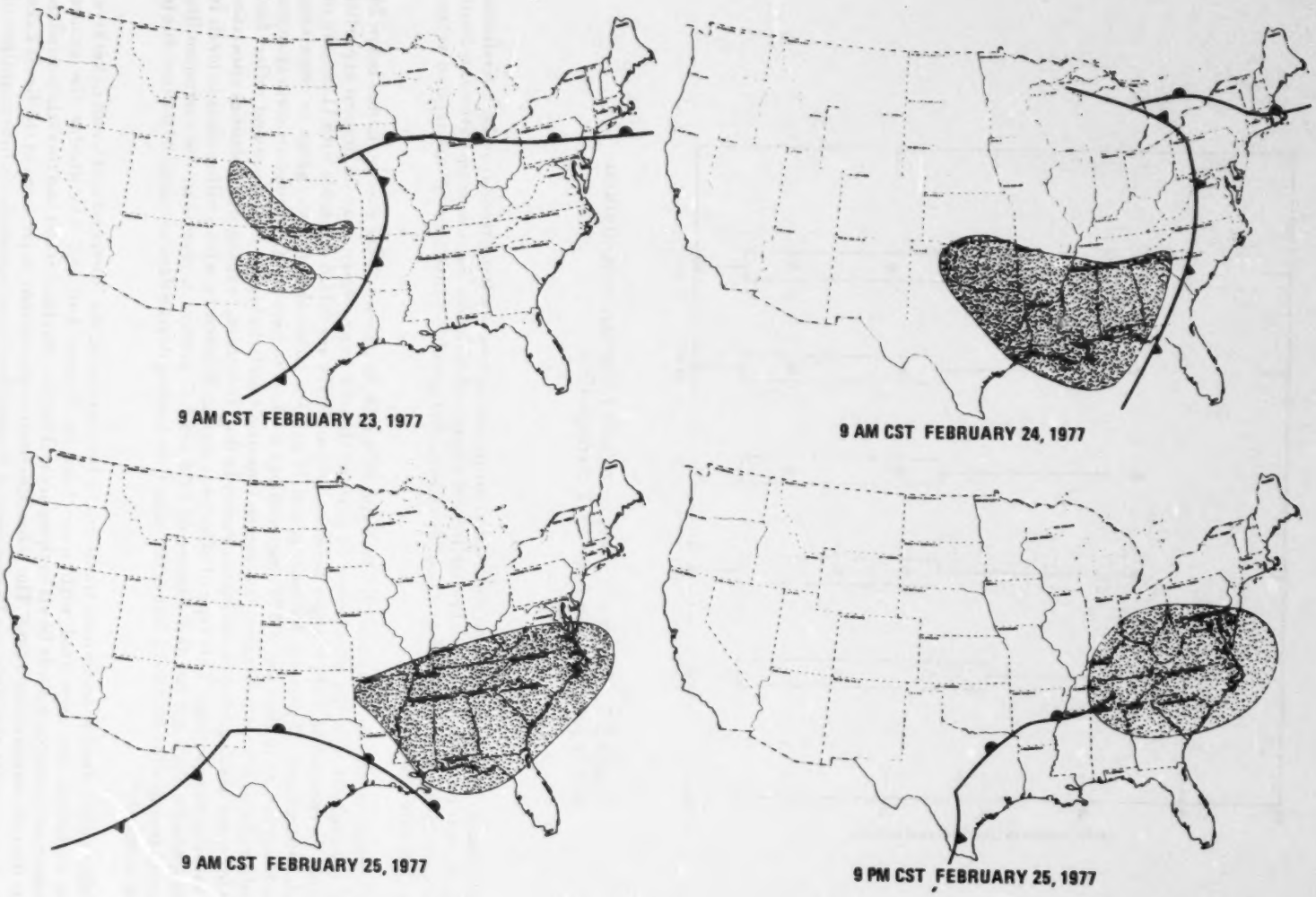

Figure 3-8. Satellite views of February 23-25, 1977, dust storm at succeeding time periods.

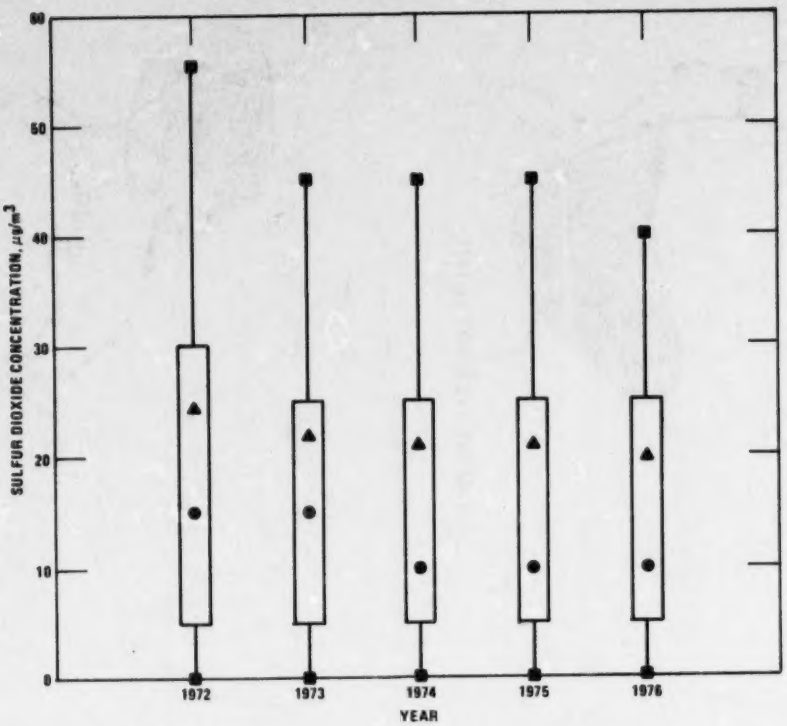

Figure 3-9. Trends of annual mean sulfur dioxide concentrations at 722 sampling sites from 1972 through 1976.

annual primary standard. Because the annual means are so low, artificial trends can be introduced merely by changes in the manner of reporting individual values below the minimum detectable limit of the monitoring instrument. For a similar reason, changes of less than 5 $\mu g/m^3$ are treated as "no change" in this analysis.

In comparing changes between 1970-1973 and 1974-1976, 64 percent of the sites remained below 26 $\mu g/m^3$ throughout. For the other sites, 51 percent showed improvement and 23 percent reported increases. In contrast to TSP, changes between 1975 and 1976 are relatively stable with 11 percent of the sites increasing, 12 percent decreasing, and 76 percent either showing no change or remaining below 26 $\mu g/m^3$. As in the case of TSP, meteorology is likely to have an effect on short-term changes. For sulfur dioxide, heating degree-days are an important meteorological parameter and reflect fuel usage for space heating. Short-term increases may be due, therefore, to changes in emissions associated with varying meteorology. This type of effect was seen in Minnesota, where sulfur dioxide levels in Minneapolis-St. Paul for the fall quarter of 1976 were 17 percent higher than the corresponding quarterly averages for 1973-1975, but at the same time heating degree-days increased 23 percent due to colder weather.[12]

Urban sulfur dioxide levels have traditionally been higher in the Northeast and Great Lakes areas where emissions are associated with space heating. Figures 3-10 and 3-11 display the general improvement in sulfur dioxide levels in those areas. The New England States had no violations of the sulfur dioxide standards in 1976.[17] There has also been improvement in portions of the Great Lakes States. For example, the Michigan Department of Natural Resources reported only four counties with

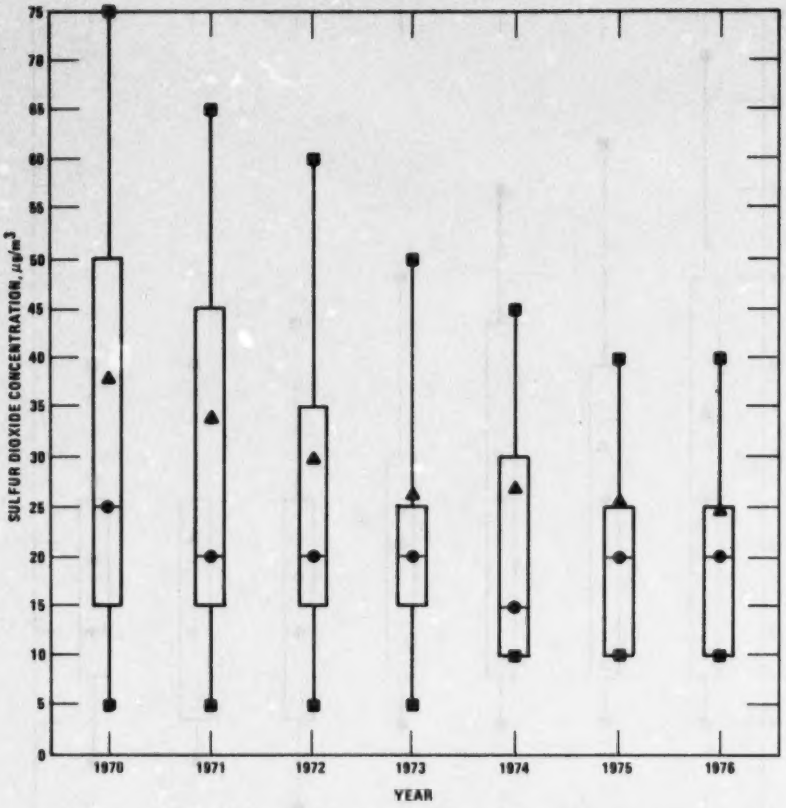

Figure 3-10. Trends of annual mean sulfur dioxide concentrations at 60 sites in New England from 1970 through 1976.

violations of the sulfur dioxide standards in 1976. For Illinois, 1976 was the first year in the history of the Illinois EPA that no monitoring site in their State violated the sulfur dioxide annual primary standard.[9]

As discussed in previous reports,[3-6] the general improvement in sulfur dioxide levels is indicative of trends in urban areas. At the present time, the remaining sulfur dioxide problems are primarily associated with specific sources impacting their surrounding areas. These situations are more commonly investigated by special studies rather than long-term trend monitoring programs.

3.3 TRENDS IN CARBON MONOXIDE

There has been general improvement in carbon monoxide (CO) levels through 1976. As discussed in previous reports,[5,6] the historical data base for CO is very limited compared to those for TSP and sulfur dioxide. The nationwide data base for CO continues to expand, an indication of the increased monitoring activities of State and local agencies during the 1970's. For example, in last year's trends report,[6] 102 sites had 3 or more years of data while 202 sites met this criteria for this year's report. The State of California with its well established monitoring program remains the major contributor to the CO data base with 59 sites qualifying as trends sites.

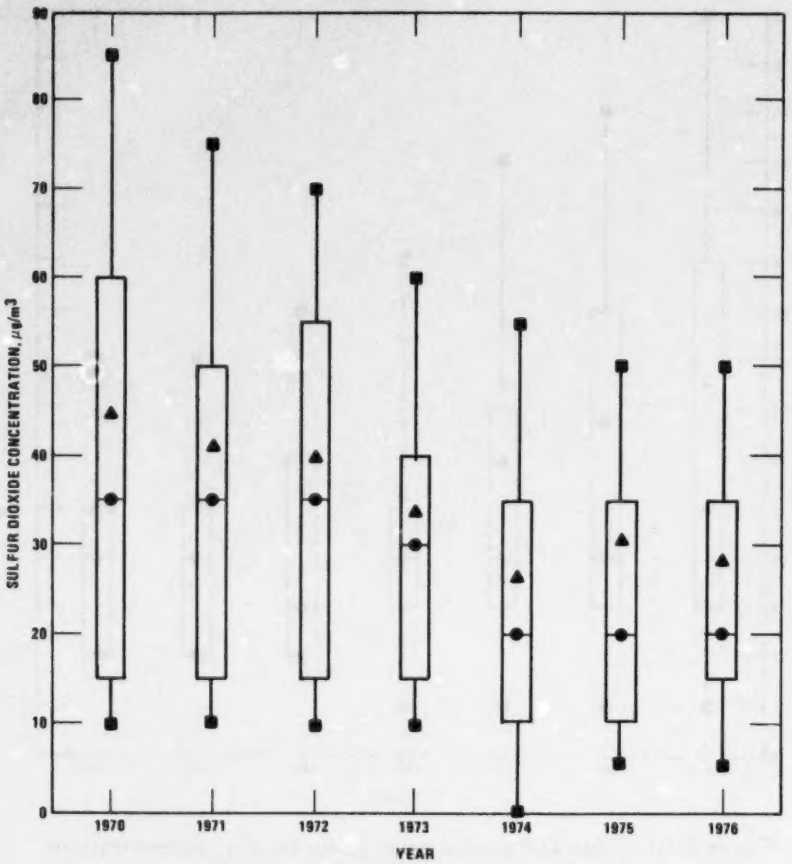

Figure 3-11. Trends of annual mean sulfur dioxide concentrations at 160 sites in Great Lakes area from 1970 through 1976.

Changes in CO levels were determined for each site by nonparametric regression. The parameter used was the annual 90th percentile of the 8-hour CO averages. The 8-hour averages rather than hourly averages are used because the 8-hour standard is more frequently exceeded. The choice of the 90th percentile is somewhat of a compromise. A desirable trend parameter should reflect whether consistent progress is being made with respect to the standards; however, the maximum or second highest 8-hour value may fluctuate from year to year because of unusual meteorology or a few traffic jams so that progress being made in reducing the extent of the CO problem is masked. The percent of time that the 8-hour standard is exceeded is also a useful parameter, but for those sites that are very close to the standard, this can occasionally be misleading. For example, a site with only one violation one year and two the next would show a 100 percent increase, but would not really be indicative of that dramatic a deterioration. The 90th percentile means that only 10 percent of the 8-hour averages were higher. It is more stable as a trend indicator than the maximum and yet still indicates what changes are occurring in the higher 8-hour averages at the site. Figure 3-12 indicates the relationship among the maximum, the 90th percentile and the percent of time above the standard for 8-hour averages for the downtown Los Angeles site. This illustrates the 90th percentile changes are consistent with the patterns seen in the other parameters.

During the 1970-1976 period, approximately three-fourths of these CO sites showed improvement. Table 3-1 summarizes these changes for all sites and also for just those sites with 5 or more years of data. Both the California and non-California sites had approximately the same percentage of increases

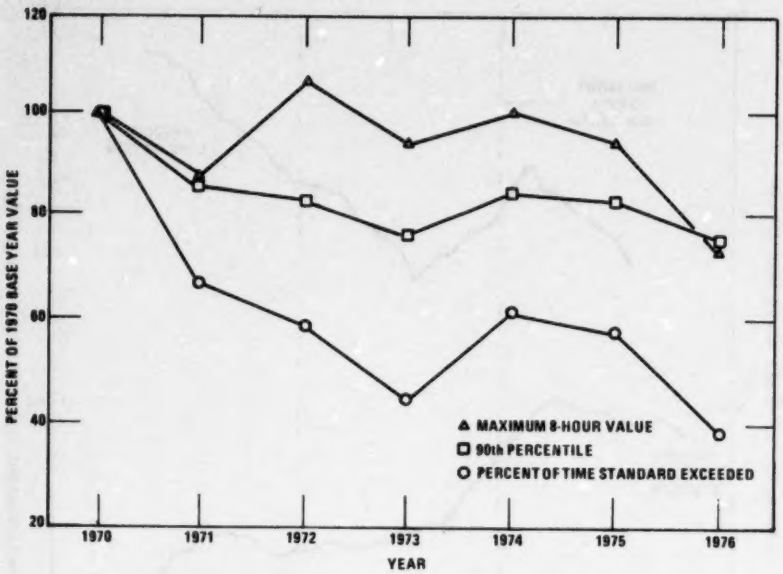

Figure 3-12. Trends in three carbon monoxide parameters since 1970 for Los Angeles.

Table 3-1. PERCENT OF MONITORING SITES SHOWING INDICATED TRENDS IN 90th PERCENTILE OF 8-hour AVERAGE CO CONCENTRATIONS, 1970-1976

Years of data	Number of sites	% down	% no change	% up
3 or more	202	75	5	20
5 or more	75	79	5	16

and decreases. However, the California sites had a slightly higher median rate of improvement, 7 percent per year in California versus 6 percent per year outside California for sites with 4 years or more data.

In a comparison of 1975 and 1976 values, 52 percent of the sites showed improvement, 39 percent had increases, and 9 percent were unchanged. In fact, 49 percent of the sites reported their all-time low value in 1976.

The State of New Jersey has had an aggressive program to reduce automobile related pollution. A part of this program is an inspection/maintenance program to ensure that exhaust emission standards are being met. Figure 3-13 was prepared by the New Jersey Department of Environmental Protection

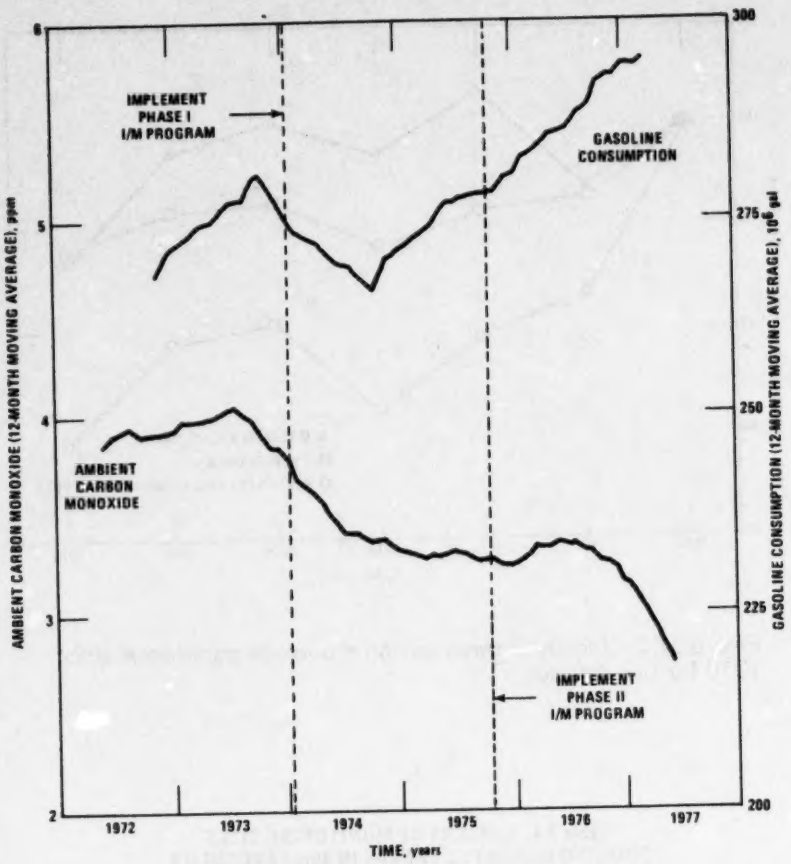

Figure 3-13. Carbon monoxide air quality from 18 monitoring sites and motor-vehicle gasoline consumption for New Jersey from 1972 through 1976.

to illustrate the progress made in reducing New Jersey CO levels from 1972 through 1977.[18] The dates for the initiation of the two phases of their inspection/maintenance program are shown. Gasoline consumption for New Jersey indicates that CO levels continue to improve despite an overall increase in gasoline consumption.

3.4 TRENDS IN PHOTOCHEMICAL OXIDANTS

Photochemical oxidant air pollution, expressed as ozone, ranks today as one of the most serious and pervasive air pollution problems in this country. In 1975, about 85 percent (356 of 416) of the O_3 sites reporting to the National Aerometric Data Bank exceeded the National Ambient Air Quality Standard (NAAQS) of 160 $\mu g/m^3$ not to be exceeded more than 1 hour per year.

In previous reports, O_3 trends assessment has been primarily limited to California sites since they were the only ones with sufficient historical data. Enough non-California sites are now available for trend purposes so that a preliminary but not a complete assessment of nationwide O_3 trends can be made. In order to qualify as a trend site, a site must have a least 3 years of data with at least 4,000

observations per year in the 1970-1976 period with the further stipulation that the 1970-1973 and 1974-1976 period each have at least 1 year of data. Nationally, 174 sites representing 34 States met this criteria - 62 in California and 112 in the remainder of the country.

The analysis of O_3 trends was done using a nonparametric regression procedure. This same procedure was also used for determining trends in the other pollutants. The trend analysis is based on the annual rate of change of the 90th percentile of the annual hourly observations. The statistic was chosen because it is more stable than either using the highest hourly value, and yet it still reflects the upper tail of the O_3 annual frequency distribution.

Table 3-2 shows the distribution of California and non-California sites into three categories of trend direction (down, no change, up). This represents merely a tabulation of the overall trend tendencies for those sites satisfying our trend criteria. Overall, the California sites do not show any predominate trend direction, instead the sites are about equally distributed between the three trend categories. Regional trends in Los Angeles and San Francisco were also mixed with no clear patterns. The overall picture obtained from the California sites, particularly in Los Angeles, is one of a steady unchanging pattern of O_3 concentrations from 1970-1976.

Table 3-2. OXIDANT/OZONE TRENDS IN 90th PERCENTILE OF ANNUAL HOURLY OBSERVATIONS 1970-1976

Direction of trend	California sites	Non-California sites	Total
Down	24	46	70
No change	16	11	27
Up	22	55	77
Total	62	112	174

The non-California sites show a slight tendency for increasing patterns with 55 sites up and 46 sites down. Table 3-3 indicates that the greater frequency of up patterns occurs in Regions IV, V, VI, and VII. For the most part, these sites represent only 3 years of data; therefore, assessing the significance of these patterns is difficult. Future trend analysis will assess the validity of these findings.

Table 3-3. OXIDANT/OZONE TRENDS, 1970-1976, BY EPA REGION

	Regions										Number of sites	Percent of sites
Trend direction	I	II	III	IV	V	VI	VII	VIII	IX	X		
Down	8	9	4	5	6	2	2	5	26	3	70	40
No change	0	1	2	3	1	0	1	1	16	2	27	16
Up	3	6	4	13	10	4	8	3	25	1	77	44
No. of sites	11	16	10	21	17	6	11	9	67	6	174	
% of sites	6.3	9.2	5.7	12.1	9.8	3.4	6.3	5.2	38.5	3.4		

Figure 3-14 shows the trend in the Bay Area Air Pollution Control District (BAAPCD) of the average highest-hour oxidant concentrations for days with comparable temperature and inversion conditions.[19] By just looking at comparable days in terms of meteorology in this way, the varying effects of meteorology from year to year are greatly reduced. The BAAPCD average of six sites shows a stable pattern over the 1970-1976 period, varying from 135 $\mu g/m^3$ in 1970 and 117 $\mu g/m^3$ in 1976. Section 2.2 of this report discusses the longer-term improvement in the population exposed to high O_3 levels in the Los Angeles Metropolitan Area.

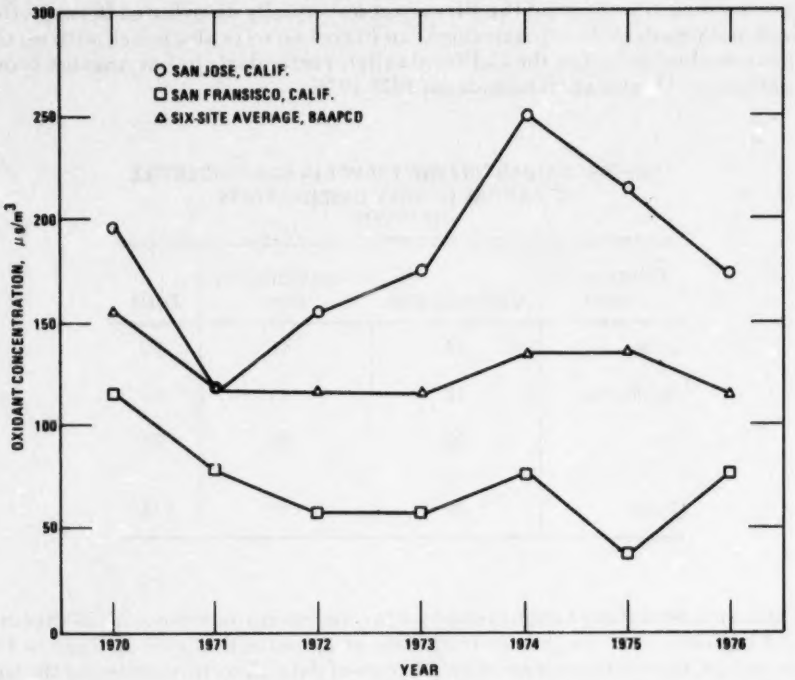

Figure 3-14. Average daily maximum-hour oxidant concentrations for days in April-October (1970-1976) having comparable temperatures and inversions in Bay Area Air Pollution Control District (BAAPCD).

Data from 174 sites were analyzed for O_3 trends over the time period 1970-1976. Sites in California did not show any consistent overall trend patterns. Trends in the Los Angeles and San Francisco areas were judged as stable over this time period.

Data from non-California sites were restricted for the most part to only 3 years of data (77 out of 112 sites). There was a little more tendency for the non-California sites to show increasing trend patterns; however, the data still remain too limited in both the number of years reporting and from a geographic standpoint to determine whether these patterns are real.

3.5 TRENDS IN NITROGEN DIOXIDE

Trends in the annual mean concentrations of nitrogen dioxide were investigated for 276 sites throughout the country for the period 1970-1976. Forty-two of these sites were located in California. Sites were selected for the trend analysis if they had at least 3 years of data with at least 4,000 observations per year in the study period. At least 1 year had to be in both the 1970-1973 and 1974-1976 periods of time in order for a site to pass the trend criteria.

Table 3-4 summarizes the NO_2 trend patterns observed at the 276 sites. Among the 42 California sites, 19 were in the down and 19 in the up categories. the non-California sites, on the other hand, show almost twice as many sites (145 to 77) with up than down patterns. Most of the non-California sites (228 out of the 234),however, had only 3 years of data so that it is impossible now to draw any definite conclusions from these findings.

Table 3-4. NITROGEN DIOXIDE TRENDS IN ANNUAL ARITHMETIC MEAN, 1970-1976

Direction of trend	California sites	Non-California sites	Total
Down	19	77	96
No change	4	12	16
Up	19	145	164
Total	42	234	276

Figure 3-15 shows the trends in NO_2 in the Los Angeles and San Francisco areas. The Los Angeles average of nine sites shows a decline in NO_2 concentrations overall for the 1970-1976 period, with a reversal of this pattern occurring in 1975 and 1976. The highest site in the L.A. Basin (Burbank) and the lowest site (Azusa) are also plotted. The San Francisco sites, on the other hand, show a more stable pattern. The average represents six sites in the San Francisco area.

3.6 ACKNOWLEDGMENTS

The Monitoring and Data Analysis Division wishes to acknowledge the contributions of Tom Curran, Bob Faoro, Sherry Olson, and Henry Cole in the preparation of Section 3, as well as the contributions made by EPA's Regional Offices during the review process. Special mention should be made of the contributions of Barry Gilbert (EPA-Region IV), and Ed Klappenbach and Steve Goranson (EPA-Region V) for their special studies. Of course, the largest debt of gratitude is due the many State and local agencies whose monitoring programs and reports make this type of analysis possible.

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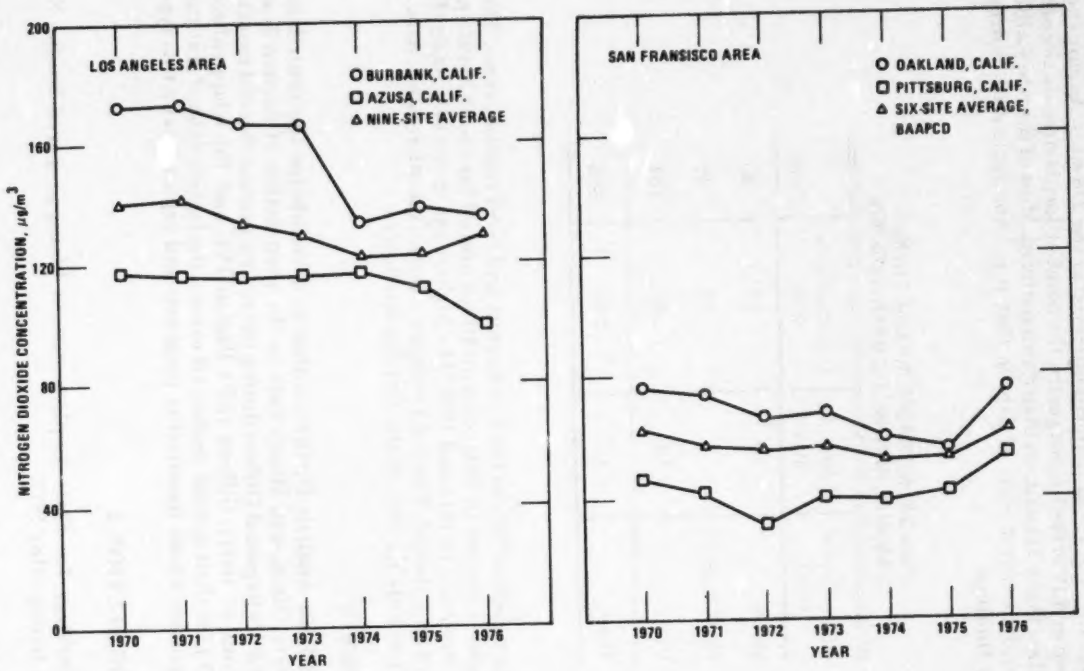

Figure 3-15. Nitrogen dioxide trends in Los Angeles and San Francisco, California, areas, 1970-1976.

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4. AIR QUALITY MAPS OF UNITED STATES

This section deals with a special topic, the geographical variations in air quality across the United States. Three multi-color air quality maps are presented, one dealing with total suspended particulate (TSP), a second with sulfur dioxide, and a third with photochemical oxidants. The maps are provided to respond to the often asked question: "How does air quality vary across the United States?"

Each of the maps indicates pollutant-specific summary statistics by county for the United States. The summary statistics relate to appropriate pollutant-specific National Ambient Air Quality Standards (NAAQS). In order to make the greatest use of available air quality data, the highest yearly statistic occurring within a county over the period 1974-1976 was used. The TSP and SO_2 air quality maps reflect data that were available from the U.S. Environmental Protection Agency's National Aerometric Data Bank (NADB) in September 1977. These data were supplemented with updated information from State reports, which were provided by the Regional Offices. The O_3 map reflects information on the NADB as of mid-October, supplemented with information obtained from a special report on O_3 data.[1]

These maps should not be used to determine non-attainment areas because the maps have been created to reflect the highest measured ambient concentrations in the 3-year period, and more current information may show that the counties are or are not violating standards. Such is the case in the counties encompassing the Metropolitan New York City area. The TSP map shows air quality exceeding the annual mean NAAQS based on 1974 data, but the population exposure analysis in Section 2.1 shows that only one site in New Jersey was violating the annual primary NAAQS in 1976. The reader must keep in mind that corrective action may have been already taken in other situations as well. A discussion of the pollutant-specific maps follows.

4.1 TOTAL SUSPENDED PARTICULATE AIR QUALITY MAP

The highest annual geometric mean measured in a county in the period 1974-1976 was used as the summary statistic. The annual mean was selected because it is less likely to be influenced by fugitive dust than would be a second-high 24-hour average. The four color categories (Figure 4-1) compare the worst annual TSP mean to levels above and below the primary annual geometric mean NAAQS of 75 $\mu g/m^3$, which is not to be exceeded. Counties colored in blue recorded measurements less than one-half the annual standard, while the counties colored in green reflect a TSP annual mean greater than one-half the annual NAAQS but less than the annual standard. Counties colored in yellow reflect a high TSP value clearly violating the standard, but less than or equal to 100 $\mu g/m^3$, while counties in red reflect a high TSP value exceeding 100 $\mu g/m^3$.

A total of 1197 counties had one or more annual means during the 1974-1976 period so that they could be displayed on the map. Of these, 355 had annual means clearly violating the annual primary NAAQS. The counties with TSP levels exceeding the annual NAAQS can be found throughout the United States. The southwestern corner of the United States, made up of California, Arizona and part of New Mexico, appears to have extensive violations. This, to some extent, is due to the nature of the analysis, for this part of the country comprises the counties with the largest land area. San Bernadino County, California, for example, is larger in land area than the combined States of Massachusetts, Connecticut, and Rhode Island. Since the analysis is based on the worst annual mean measured in the county, greater attention is drawn to the air quality in these large counties.

4.2 SULFUR DIOXIDE AIR QUALITY MAP

The annual second-highest 24-hour average sulfur dioxide measurement was the statistic used to characterize sulfur dioxide concentrations. The maximum statistic occurring within a county in the

1974-1976 time period is represented on the sulfur dioxide air quality map (Figure 4-2). This statistic relates to the short-term 24-hour average standard of 365 $\mu g/m^3$, which is not to be exceeded more than once per year. This was used instead of the annual mean, which could be compared to the SO_2 annual mean primary NAAQS, because many SO_2 monitors did not collect sufficient data to meet the NADB validity criteria for calculating an annual mean. The criteria require that at least 75 percent of the total possible data be available to calculate an annual mean. Further, the 24-hour average NAAQS is more likely to be violated than the annual standard.

An examination of the sulfur dioxide map indicates that most areas of the country are not showing violations of the short-term NAAQS. Of the 834 counties with SO_2 data, 60 had second-highest 24-hour averages exceeding the 24-hour primary standard. Most of these occurred in the industrial areas of the Midwest. Other violations can be seen in the western part of the United States where the principal sources are smelting operations.

4.3 PHOTOCHEMICAL OXIDANT AIR QUALITY MAP

The annual second-highest daily maxima of 1-hour oxidant measurements were the statistics used to characterize photochemical oxidant concentrations. The maximum statistic occurring within a county in the 1974-1976 time period is represented on the photochemical oxidant air quality map (Figure 4-3). This statistic relates to the 1-hour average O_3 NAAQS of 160 $\mu g/m^3$, which is not to be exceeded more than once per year. It is a more stable statistic for geographical comparisons than the second-highest hourly average observed within a year. The latter can be more easily influenced by a day with unusually abnormal meteorological conditions that are conducive to high O_3 levels. As indicated earlier, the O_3 maps reflect information available on the NADB as of mid-October 1977, supplemented with information obtained from a special report on O_3 data collected in rural areas.[1]

Counties with an oxidant statistic less than the NAAQS are colored in blue, while counties colored in purple show O_3 statistics greater than one but less than two times the NAAQS. Pink counties show greater than two times the standards, but less than three times the standard, while red counties have O_3 statistics in excess of three times the NAAQS.

From the map, it can be seen that the O_3 problem is widespread and standards are being violated in most areas where O_3 is being measured. The counties in which monitoring is taking place represent 50.2 percent of the population of the United States. Approximately 99 percent of these people live in counties where the photochemical oxidant standard was violated. The counties colored in blue, for the most part, are in remote rural areas and their oxidant statistics are close to the standard.

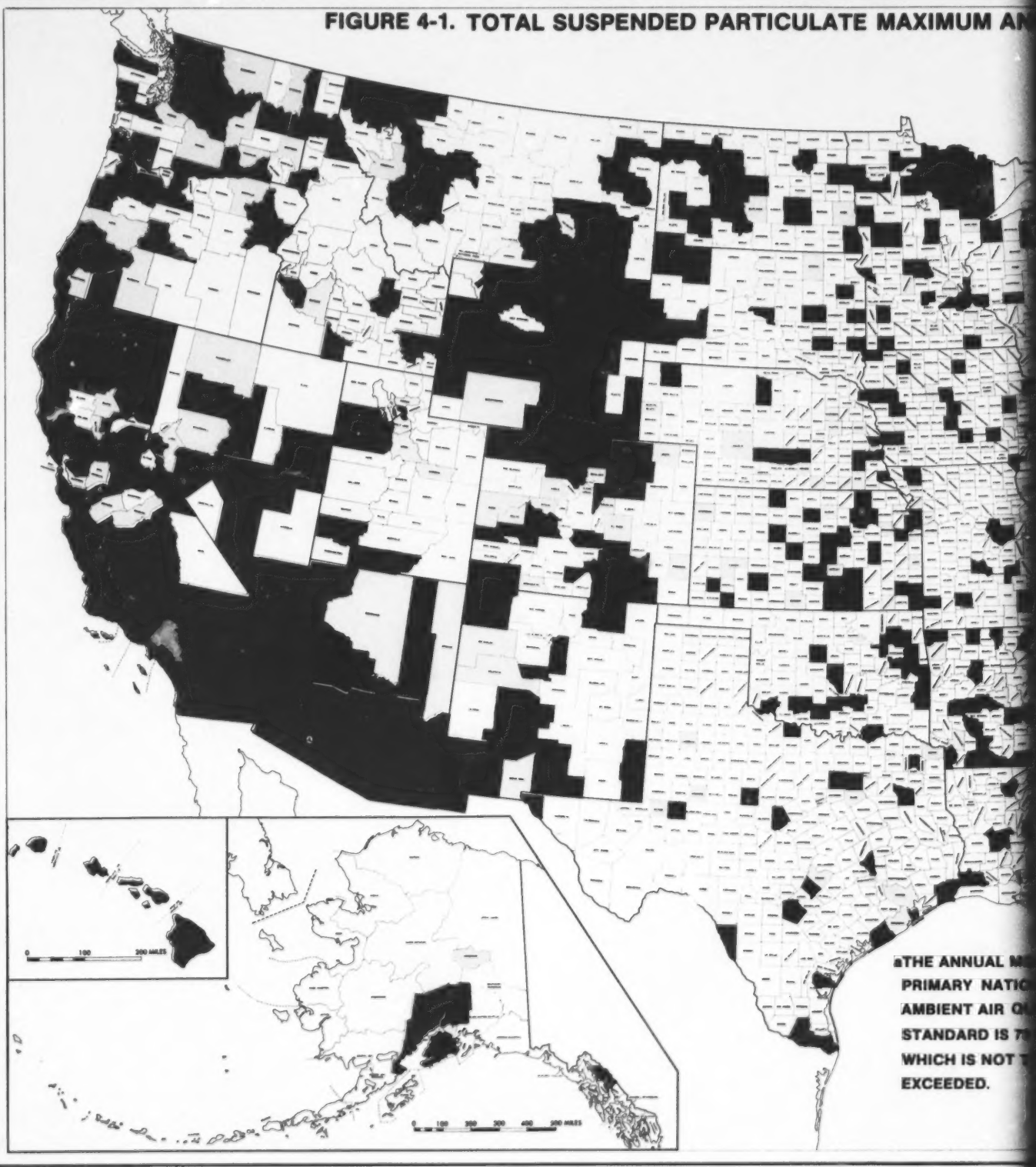
4.4 ACKNOWLEDGMENTS

The Monitoring and Data Analysis Division would like to recognize the contributions made by William F. Hunt, Jr., Robert B. Faoro, Virginia Henderson, Jerome Mersch, Hersh Rorex, Warren Freas, Thomas Curran, Sherry Olson, Margaret Swann, James Capel, and Jeff Smith. Mr. Charles Keadle of the Office of Administration deserves special recognition for the artwork he prepared. The section would not have been possible without support received from the Regional Offices. Specifically, the Division would like to recognize Jean Kelleher, Region I; Lew Heckman, Region II; Sandor Kovacs, Region III; Barry Gilbert, Region IV; Steve Goranson and Larry Lehrman, Region V; Miguel Flores, Region VI; Charles Whitmore, Region VII; Barry Levene, Region VIII; Coe Owen, Region IX; and George Hofer, Region X.

4.5 REFERENCE FOR SECTION 4

1. "Compilation and Evaluation of Privately Collected Ambient Ozone Data West of the Mississippi River," prepared by PEDCo Environmental, Inc., Kansas City, Missouri for the U.S. Environmental Protection Agency, Monitoring and Data Analysis Division, Research Triangle Park, N.C. 27711, April 1977.

FIGURE 4-1. TOTAL SUSPENDED PARTICULATE MAXIMUM AN



aTHE ANNUAL M
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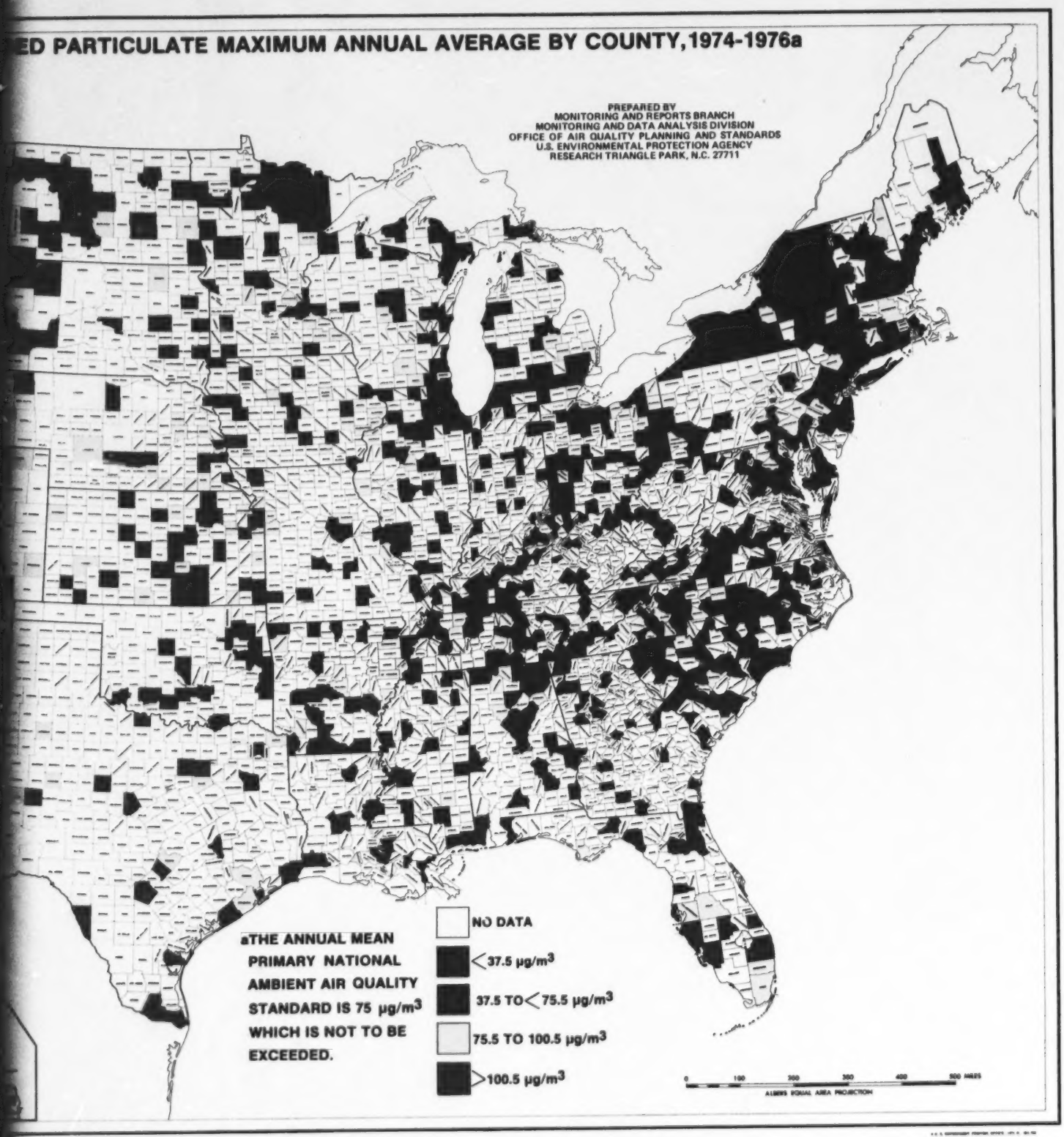
EXCEEDED.

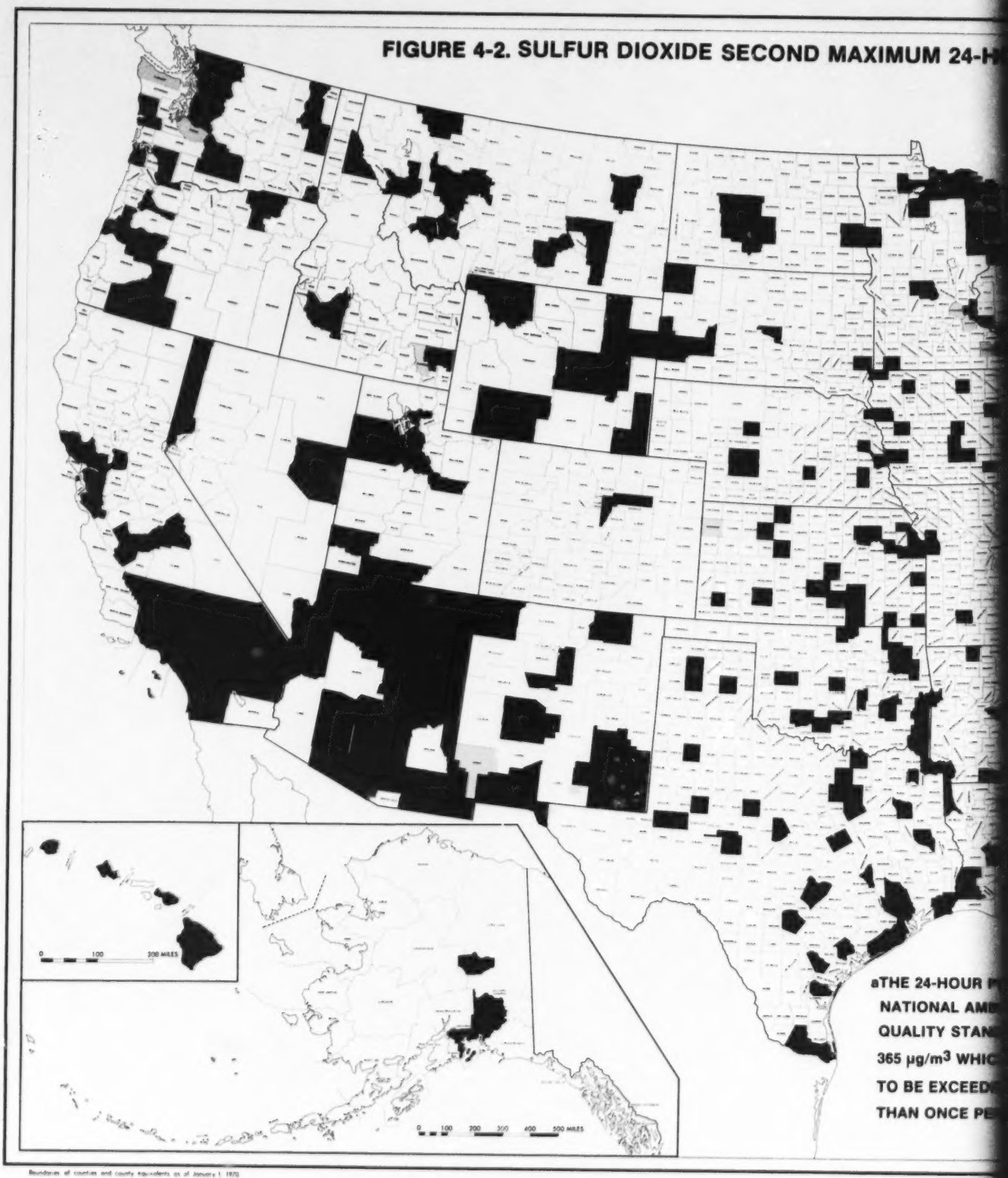
Boundaries of counties and county equivalents as of January 1, 1970

A


ED PARTICULATE MAXIMUM ANNUAL AVERAGE BY COUNTY, 1974-1976a
PREPARED BY
MONITORING AND REPORTS BRANCH
MONITORING AND DATA ANALYSIS DIVISION
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, N.C. 27711
aTHE ANNUAL MEAN PRIMARY NATIONAL AMBIENT AIR QUALITY STANDARD IS 75 µg/m3 WHICH IS NOT TO BE EXCEEDED.
NO DATA
<37.5 µg/m3
37.5 TO <75.5 µg/m3
75.5 TO 100.5 µg/m3
>100.5 µg/m3
0 100 200 300 400 500 MILES
ALBERS EQUAL AREA PROJECTION

B

FIGURE 4-2. SULFUR DIOXIDE SECOND MAXIMUM 24-H



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Boundaries of counties and county equivalents as of January 1, 1970

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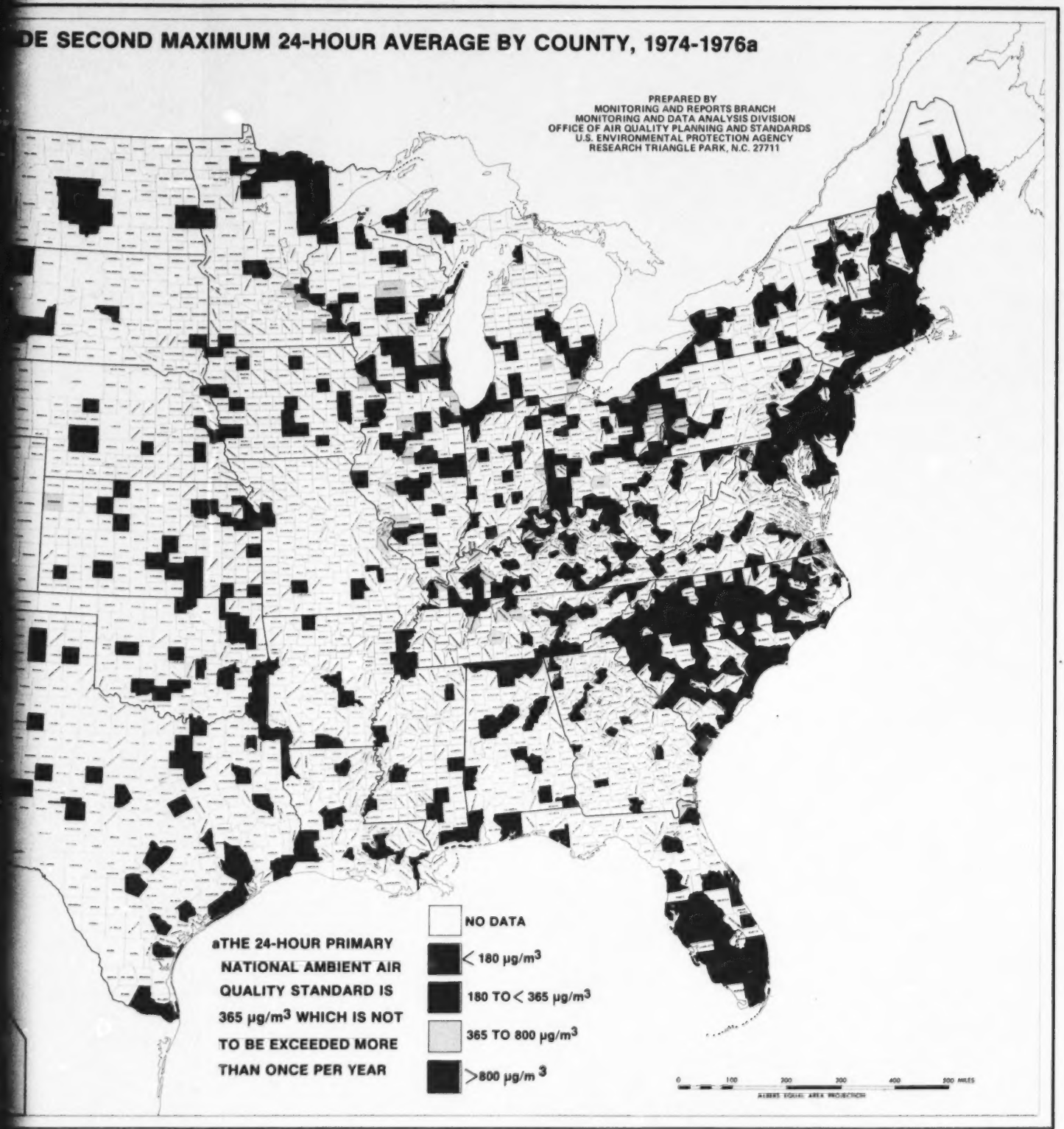
DE SECOND MAXIMUM 24-HOUR AVERAGE BY COUNTY, 1974-1976a
PREPARED BY
MONITORING AND REPORTS BRANCH
MONITORING AND DATA ANALYSIS DIVISION
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, N.C. 27711
aTHE 24-HOUR PRIMARY NATIONAL AMBIENT AIR QUALITY STANDARD IS 365 μg/m3 WHICH IS NOT TO BE EXCEEDED MORE THAN ONCE PER YEAR
NO DATA
< 180 μg/m3
180 TO < 365 μg/m3
365 TO 800 μg/m3
>800 μg/m 3
0 100 200 300 400 500 MILES
ALBERS EQUAL AREA PROJECTION

B

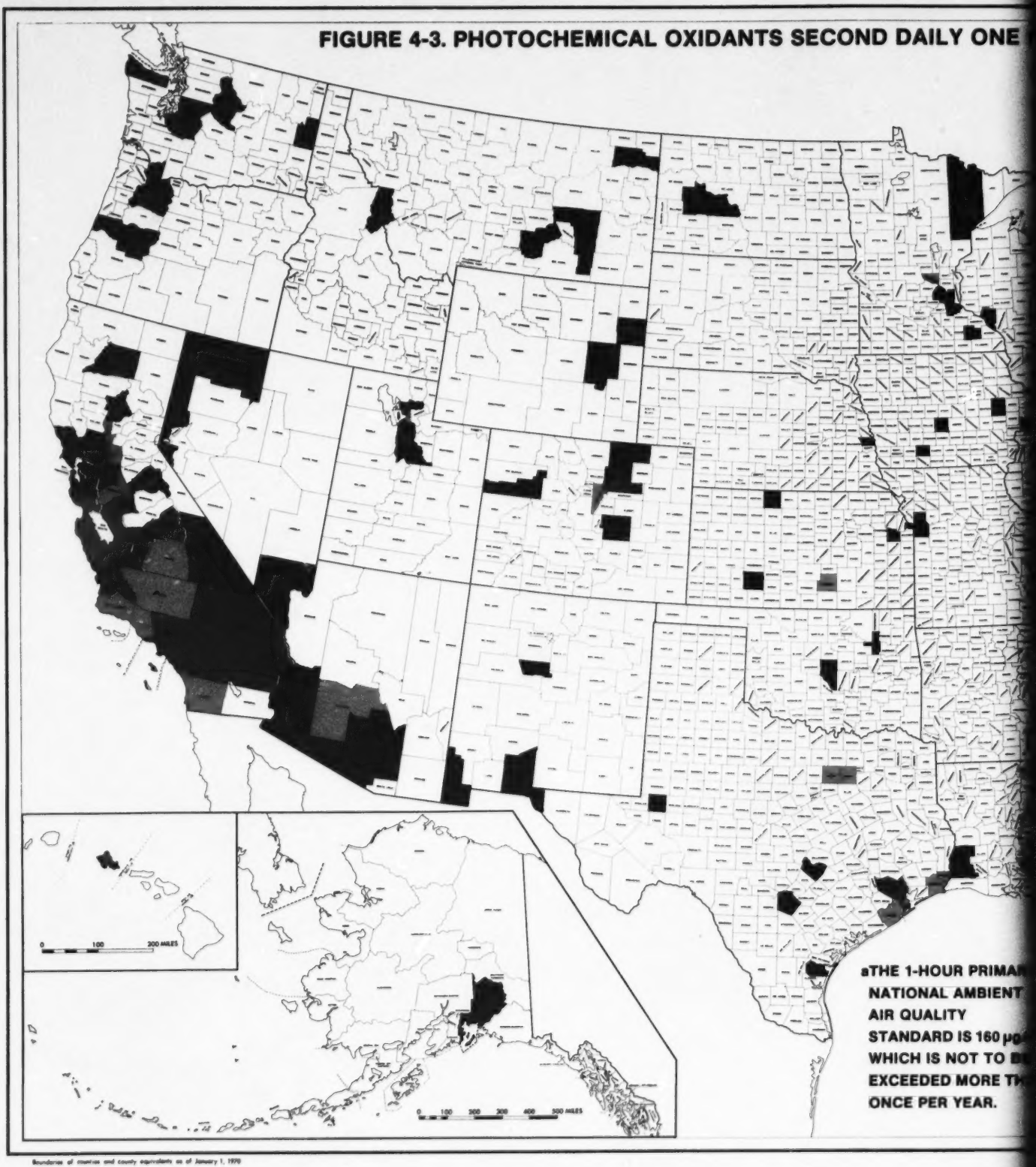
FIGURE 4-3. PHOTOCHEMICAL OXIDANTS SECOND DAILY ONE
0 100 200 MILES
0 100 200 300 400 500 MILES
aTHE 1-HOUR PRIMA
NATIONAL AMBIENT
AIR QUALITY
STANDARD IS 160 µg
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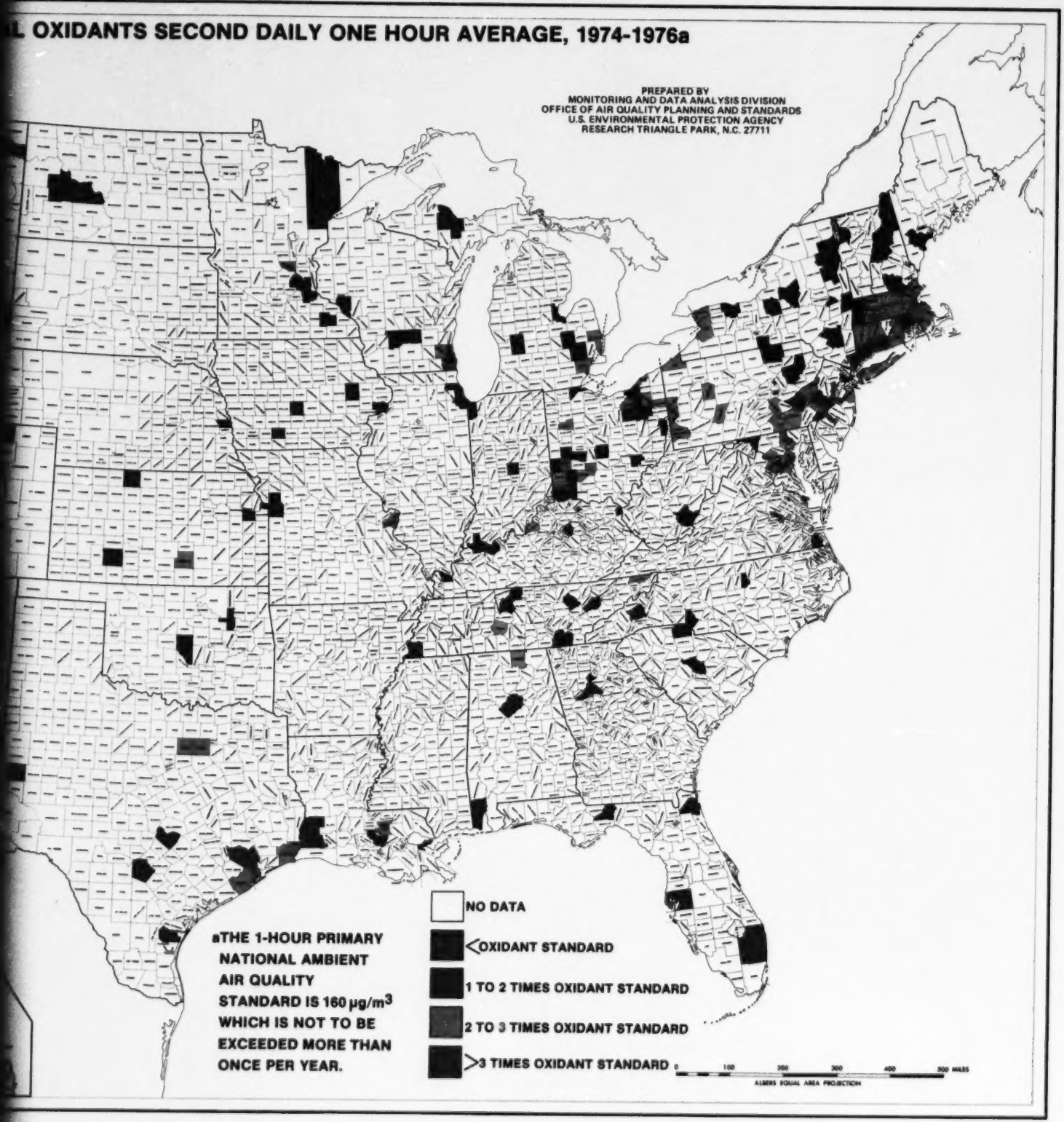
EXCEEDED MORE TH
ONCE PER YEAR.
Boundaries of counties and county equivalents as of January 1, 1970

A


L OXIDANTS SECOND DAILY ONE HOUR AVERAGE, 1974-1976a
PREPARED BY
MONITORING AND DATA ANALYSIS DIVISION
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, N.C. 27711
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>3 TIMES OXIDANT STANDARD
aTHE 1-HOUR PRIMARY NATIONAL AMBIENT AIR QUALITY STANDARD IS 160 µg/m3 WHICH IS NOT TO BE EXCEEDED MORE THAN ONCE PER YEAR.
0 100 200 300 400 500 MILES
ALBERS EQUAL AREA PROJECTION

5. NATIONWIDE EMISSION ESTIMATES, 1970-1976

Table 5-1 summarizes estimated national emissions of total suspended particulates (TSP), sulfur oxides (SO_x), nitrogen oxides (NO_x), hyrocarbons (HC), and carbon monoxide (CO). Because of modifications in methodology and use of more refined emission factors, data from the following table should not be compared with data in previous reports.[1]

Table 5-1. SUMMARY OF NATIONAL EMISSION ESTIMATES, 1970-1976
(10^6 metric tons/year)

Year	TSP	SO_x	NO_x	HC	CO
1970	22.6	29.1	20.4	29.7	99.8
1971	21.4	27.9	21.3	29.3	100.2
1972	20.3	28.8	22.2	29.7	102.0
1973	19.9	29.7	22.9	29.8	98.3
1974	17.5	28.2	22.6	28.6	91.5
1975	14.4	25.7	22.2	26.2	85.9
1976	13.4	26.9	23.0	27.9	87.2

Two distinctions between these emission estimates and ambient pollutant measurements should be noted. First, the emission estimates for particulates, sulfur oxides, and nitrogen oxides embrace a broader range of substances than are measured by routine ambient air monitoring equipment. The high-volume air sampler collects only the particulates suspended in air that range from approximately 0.3 to 100 micrometers in diameter, but emission inventories include both suspended and settled particulates generated by man's activities. Sulfur dioxide and nitrogen dioxide ambient air monitors measure only those two specific compounds, not all the oxides of sulfur and nitrogen included in emission estimates. In each case, however, the compound actually measured is the most prevalent constituent of its pollutant class or is acknowledged to be its most representative indicator. Second, the tables of estimated emissions include hydrocarbons, but not oxidants. Obviously, oxidant emissions would not be meaningful because the overwhelming majority of oxidants are so-called secondary pollutants generated by photochemical reactions in the atmosphere. Emissions of hydrocarbons are important because hydrocarbons are a major ingredient for those oxidant-producing reactions; yet, ambient measurements of hydrocarbon are not reported because a reliable method has not yet been developed for the continuous monitoring of this large and diverse class of compounds. Consequently, monitoring is not required. Hydrocarbon emission estimates reported herein are basically for total hydrocarbons, as defined by currently available emission factors.[2] Sources that emit only methane are generally not included. Sources that emit a mixture of hydrocarbons, including methane, would include methane in the total hydrocarbon emission estimates.

5.1 DETAILED ANNUAL EMISSION ESTIMATES

Tables 5-2 through 5-8 present annual emission estimates according to major source categories. These data are estimated from published data on fuel use and industrial production, other EPA data such as air pollutant emission factors, and available information on the extent of air pollution controls employed.[3-6]

Table 5-2. NATIONWIDE EMISSION ESTIMATES, 1970
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.1	0.7	8.4	12.6	79.2
Highway vehicles	0.7	0.3	6.3	11.1	69.7
Non-highway vehicles	0.4	0.4	2.1	1.5	9.5
Stationary fuel combustion	7.1	22.3	10.9	1.5	1.2
Electric utilities	4.1	15.7	5.1	0.1	0.2
Industrial	2.6	4.6	5.1	1.3	0.5
Residential, commercial & institutional	0.4	2.0	0.7	0.1	0.5
Industrial processes	12.4	5.9	0.6	8.5	8.0
Chemicals	0.3	0.5	0.2	1.5	3.0
Petroleum refining	0.1	0.6	0.3	0.7	2.0
Metals	2.1	4.1	0	0.2	2.1
Mineral products	7.7	0.5	0.1	0	0
Oil & gas production and marketing	0	0.1	0	2.7	0
Industrial organic solvent use	0	0	0	2.7	0
Other processes	2.2	0.1	0	0.7	0.9
Solid waste	1.1	0.1	0.3	1.7	6.1
Miscellaneous	0.9	0.1	0.2	5.4	5.3
Forest wildfires and managed burning	0.5	0	0.1	0.7	3.5
Agricultural burning	0.3	0	0	0.3	1.4
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.3	0
Total	22.6	29.1	20.4	29.7	99.8

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

The "Transportation" category includes emissions from all mobile sources. Highway vehicles include passenger cars, trucks, and buses. Non-highway vehicles include aircraft, railroads, vessels, and miscellaneous mobile engines such as farm equipment, industrial and construction machinery, lawnmowers, and snowmobiles.

"Stationary Fuel Combustion" is defined to be all fuel use in stationary combustion equipment such as boilers and stationary internal combustion engines. Emissions are shown for electric utility power plants, industrial establishments, and other fuel consumers (residential, commercial, governmental, and schools).

"Industrial Processes" includes emissions resulting from operation of process equipment by manufacturing industries. In addition, the categories "Oil and Gas Production and Marketing" (crude oil and natural gas production, petroleum storage tanks and transfer facilities, gasoline service stations) and "Industrial Organic Solvent Use" (surface coating and degreasing of manufactured

Table 5-3. NATIONWIDE EMISSION ESTIMATES, 1971
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.1	0.7	8.9	12.3	79.6
Highway vehicles	0.7	0.3	6.7	10.8	70.3
Non-highway vehicles	0.4	0.4	2.2	1.5	9.3
Stationary fuel combustion	6.6	21.5	11.2	1.5	1.2
Electric utilities	4.0	15.6	5.4	0.1	0.2
Industrial	2.2	4.0	5.1	1.3	0.5
Residential, commercial & institutional	0.4	1.9	0.7	0.1	0.5
Industrial processes	11.8	5.5	0.6	8.5	7.9
Chemicals	0.3	0.5	0.2	1.4	2.7
Petroleum refining	0.1	0.6	0.3	0.7	2.1
Metals	1.9	3.6	0	0.2	2.2
Mineral products	7.3	0.6	0.1	0	0
Oil & gas production and marketing	0	0.1	0	2.8	0
Industrial organic solvent use	0	0	0	2.7	0
Other processes	2.2	0.1	0	0.7	0.9
Solid waste	0.8	0.1	0.3	1.4	4.7
Miscellaneous	1.1	0.1	0.3	5.6	6.8
Forest wildfires and managed burning	0.7	0	0.2	1.0	5.1
Agricultural burning	0.2	0	0	0.3	1.3
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.2	0
Total	21.4	27.9	21.3	29.3	100.2

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

products, printing and publishing) are included under industrial processes. "Other Processes" represents combined emissions from pulp and paper, wood products, agricultural, rubber and plastics, and textile industries. "Solid Waste" includes emissions from combustion of waste in municipal and other incinerators, and open burning of domestic and municipal refuse.

"Miscellaneous" includes emissions from combustion of forest, agricultural and coal refuse materials, and structural fires. Also included are estimated emissions from consumption of organic solvents not accounted for in industrial processing operations. This includes trade sales of surface coatings, dry cleaning, cutback asphalt paving, and other commercial and domestic consumption of organic solvents.

Table 5-4. NATIONWIDE EMISSION ESTIMATES, 1972
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.2	0.7	9.4	12.6	84.0
Highway vehicles	0.8	0.3	7.1	11.0	74.8
Non-highway vehicles	0.4	0.4	2.3	1.6	9.2
Stationary fuel combustion	6.4	21.8	11.7	1.5	1.3
Electric utilities	4.0	16.0	5.9	0.1	0.3
Industrial	2.0	4.0	5.1	1.3	0.5
Residential, commercial & institutional	0.4	1.8	0.7	0.1	0.5
Industrial processes	11.1	6.1	0.7	8.9	7.9
Chemicals	0.3	0.6	0.3	1.5	2.6
Petroleum refining	0.1	0.7	0.3	0.7	2.1
Metals	1.9	4.0	0	0.2	2.2
Mineral products	6.7	0.6	0.1	0	0
Oil & gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	2.9	0
Other processes	2.1	0.1	0	0.7	1.0
Solid waste	0.7	0.1	0.2	1.1	4.0
Miscellaneous	0.9	0.1	0.2	5.6	4.8
Forest wildfires and managed burning	0.5	0	0.1	0.7	3.6
Agricultural burning	0.2	0	0	0.2	0.8
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.6	0
TOTAL	20.3	28.8	22.2	29.7	102.0

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

5.2 EMISSION TRENDS

Overall, from data in Table 5-1, it can be determined that from 1970 through 1976, emissions of particulates decreased by 40 percent, sulfur oxides decreased by 8 percent, nitrogen oxides increased by 13 percent, hydrocarbons decreased by 6 percent, and carbon monoxide decreased by 13 percent. Since these data are only calculated estimates of emissions on a nationwide scale, trends in emissions for local areas may be entirely different. Nevertheless, national emission estimates should be indicative of the overall general trend in the quantities of air pollutants released to the atmosphere.

Particulate emissions from 1970 to 1976 have been substantially reduced by installation of control equipment on industrial processes and large stationary fuel combustion sources that burn coal. In addition, particulate emissions have decreased because of lower quantities of coal consumed by small industrial and other fuel combustion sources, and less burning of solid waste.

Table 5-5. NATIONWIDE EMISSION ESTIMATES, 1973
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.2	0.8	9.7	12.2	81.3
Highway vehicles	0.8	0.4	7.3	10.6	72.0
Non-highway vehicles	0.4	0.4	2.4	1.6	9.3
Stationary fuel combustion	6.5	22.9	12.1	1.6	1.3
Electric utilities	4.3	17.5	6.3	0.1	0.3
Industrial	1.8	3.7	5.1	1.4	0.5
Residential, commercial & institutional	0.4	1.7	0.7	0.1	0.5
Industrial processes	10.9	5.8	0.7	9.4	8.7
Chemicals	0.3	0.5	0.3	1.6	2.8
Petroleum refining	0.1	0.8	0.3	0.8	2.2
Metals	2.1	3.7	0	0.2	2.2
Mineral products	6.3	0.6	0.1	0	0
Oil & gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	3.1	0
Other processes	2.1	0.1	0	0.8	1.0
Solid waste	0.6	0.1	0.2	1.0	3.6
Miscellaneous	0.7	0.1	0.2	5.6	3.9
Forest wildfires and managed burning	0.4	0	0.1	0.6	2.9
Agricultural burning	0.1	0	0	0.1	0.6
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.8	0
Total	19.9	29.7	22.9	29.8	98.3

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

Sulfur oxide emissions have been reduced slightly from 1970 to 1976. Emissions from stationary fuel combustion sources have remained about constant while industrial process emissions have been reduced by increased recovery of sulfur at primary non-ferrous smelters. Emissions from electric utility fuel consumption have increased because of increased coal consumption. The increase is moderated by the use of coals with lower average sulfur content. Sulfur oxides emissions from other fuel combustion sectors have decreased because of less coal use by these sources.

Nitrogen oxide emissions have increased, predominantly because of increased highway vehicle travel and increased fuel combustion by electric utilities. Emissions from other sources have not changed significantly.

Hydrocarbon emissions have been reduced slightly from controls implemented on highway vehicles. Despite substantial growth in motor vehicle travel, there has been a net reduction in

Table 5-6. NATIONWIDE EMISSION ESTIMATES, 1974
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.2	0.8	9.6	11.3	74.0
Highway vehicles	0.8	0.4	7.3	9.8	65.6
Non-highway vehicles	0.4	0.4	2.3	1.5	8.4
Stationary fuel combustion	5.6	21.9	11.9	1.5	1.3
Electric utilities	3.8	17.0	6.2	0.1	0.3
Industrial	1.4	3.3	5.0	1.3	0.5
Residential, commercial & institutional	0.4	1.6	0.7	0.1	0.5
Industrial processes	9.4	5.3	0.7	9.2	8.2
Chemicals	0.3	0.4	0.3	1.6	2.5
Petroleum refining	0.1	0.8	0.3	0.8	2.3
Metals	1.9	3.3	0	0.2	2.4
Mineral products	5.4	0.6	0.1	0	0
Oil & gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	2.9	0
Other processes	1.7	0.1	0	0.8	1.0
Solid waste	0.5	0.1	0.2	0.9	3.2
Miscellaneous	0.8	0.1	0.2	5.7	4.8
Forest wildfires and managed burning	0.5	0	0.1	0.6	3.9
Agricultural burning	0.1	0	0	0.3	0.5
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.7	0
TOTAL	17.5	28.2	22.6	28.6	91.5

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

hydrocarbon emissions. Stationary source emissions have remained about constant. Increased industrial process emissions have been balanced by decreased emissions from burning of solid waste.

Carbon monoxide emissions have decreased primarily because of highway vehicle controls and less burning of solid waste. Emissions from other source categories have not changed appreciably.

Emissions in 1975 were generally lower than those in 1976 because of economic conditions in 1975 that reduced industrial production. Increased emissions from 1975 to 1976 reflect the effects of economic recovery. At the same time, increased levels of control are being applied by major sources so that particulate emissions actually decreased from 1975 to 1976 and increases in emissions of other pollutants were relatively small.

Table 5-7. NATIONWIDE EMISSION ESTIMATES, 1975
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.2	0.8	9.9	10.9	71.5
Highway vehicles	0.8	0.4	7.6	9.4	63.3
Non-highway vehicles	0.4	0.4	2.3	1.5	8.2
Stationary fuel combustion	5.3	20.6	11.2	1.4	1.2
Electric utilities	3.9	16.7	6.1	0.1	0.3
Industrial	1.1	2.5	4.5	1.2	0.5
Residential, commercial & institutional	0.3	1.4	0.6	0.1	0.4
Industrial processes	6.9	4.2	0.7	8.5	7.1
Chemicals	0.2	0.3	0.3	1.5	2.2
Petroleum refining	0.1	0.7	0.3	0.8	2.3
Metals	1.3	2.5	0	0.2	1.7
Mineral products	3.7	0.5	0.1	0	0
Oil & gas production and marketing	0	0.1	0	2.9	0
Industrial organic solvent use	0	0	0	2.4	0
Other processes	1.6	0.1	0	0.7	0.9
Solid waste	0.4	0	0.2	0.8	2.9
Miscellaneous	0.6	0.1	0.2	4.6	3.2
Forest wildfires and managed burning	0.3	0	0.1	0.4	2.3
Agricultural burning	0.1	0	0	0.1	0.5
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.0	0
Total	14.4	25.7	22.2	26.2	85.9

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

5.3 ACKNOWLEDGMENT

The Monitoring and Data Analysis Division would like to recognize Charles Mann for assembling this section of the report.

5.4 REFERENCES FOR SECTION 5

1. *National Air Quality and Emission Trends Report, 1975.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. EPA-450/1-76-002. November 1976.

2. *Compilation of Air Pollutant Emission Factors,* EPA Publication AP-42, Third Edition (including Supplements 1-7), U.S. Environmental Protection Agency, Research Triangle Park, N.C. August 1977.

Table 5-8. NATIONWIDE EMISSION ESTIMATES, 1976
(10^6 metric tons/year)

Source category	TSP	SO_x	NO_x	HC	CO
Transportation	1.2	0.8	10.1	10.8	69.7
Highway vehicles	0.8	0.4	7.8	9.3	61.4
Non-highway vehicles	0.4	0.4	2.3	1.5	8.3
Stationary fuel combustion	4.6	21.9	11.8	1.4	1.2
Electric utilities	3.2	17.6	6.6	0.1	0.3
Industrial	1.1	2.6	4.5	1.2	0.5
Residential, commercial & institutional	0.3	1.7	0.7	0.1	0.4
Industrial processes	6.3	4.1	0.7	9.4	7.8
Chemicals	0.3	0.3	0.3	1.6	2.4
Petroleum refining	0.1	0.7	0.3	0.9	2.4
Metals	1.3	2.4	0	0.2	1.9
Mineral products	3.2	0.5	0.1	0	0
Oil & gas production and marketing	0	0.1	0	3.0	0
Industrial organic solvent use	0	0	0	2.9	0
Other processes	1.4	0.1	0	0.8	1.1
Solid waste	0.4	0	0.1	0.8	2.8
Miscellaneous	0.9	0.1	0.3	5.5	5.7
Forest wildfires and managed burning	0.6	0	0.2	0.8	4.8
Agricultural burning	0.1	0	0	0.1	0.5
Coal refuse burning	0.1	0.1	0.1	0.1	0.3
Structural fires	0.1	0	0	0	0.1
Miscellaneous organic solvent use	0	0	0	4.5	0
TOTAL	13.4	26.9	23.0	27.9	87.2

Note: A zero in Tables 5-2 through 5-8 indicates emissions of less than 50,000 metric tons per year.

3. Mann, C.O. OAQPS Data Files of Nationwide Emissions, 1970-1976. Unpublished documents, National Air Data Branch, Monitoring and Data Analysis Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C. November 1977.

4. Data from Compliance Data System, Division of Stationary Source Enforcement, U.S. Environmental Protection Agency, Washington, D.C., June 1977.

5. Data from Energy Data System, Energy Strategies Branch, Strategies and Air Standards Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C. April 1977.

6. Data from National Emissions Data System, National Air Data Branch, Monitoring and Data Analysis Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C. November 1977.